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TRANSPORTATION ENERGY CONSERVATION

by

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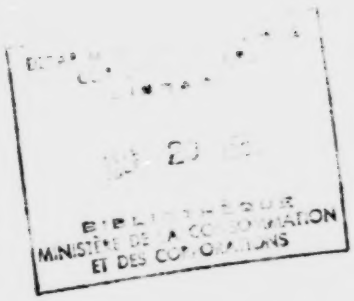

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TRANSPORTATION ENERGY CONSERVATION ACTIONS

Introduction

The main objective of this Chapter is to provide a comprehensive list of transportation energy conservation actions as they have appeared in the literature. Such a list would be as complete as possible regarding the movements of travellers and materials. It would not, however, attempt to list actions further to energy conservation in the home, factory or institutions.

Secondary objectives of this Chapter relate to the provision of brief descriptive and evaluative comments regarding the actions. These comments will assist in a main purpose of this report - the identification of a promising energy conservation action to further assess in a demonstration project. To this end, information regarding the potential energy savings of, and time to implement the action, is provided.

Several approaches were taken to identify the literature applicable to the objectives of this Chapter. Computer-assisted searches were made of on-line bibliographic data bases such as TRIS and NTIS. Systematic reviews were also made of the energy research bibliographies prepared by Anderson and his associates for the department.[1] Finally, manual searches were made of such potentially-applicable periodicals as Transportation, Transportation Research and Transportation Research Record.

The typology used in this Chapter to group and organize the transportation energy conservation actions was a consequence of the research process used to identify the actions. While several alternative typologies were identified in the literature review,[2] no one alternative was found to adequately group the numerous actions. This typology groups the actions according to the subject or focus of the action as follows:

- Land development
- Business and commerce practice
- Work activities
- Nonwork activities
- Trip generation and planning
- Transportation energy conservation information
- Mass transit
- Paratransit
- Motorcycles and mopeds
- Bicycles and pedestrians
- Automobiles
- Freight transportation
- Fuel prices and restrictions
- Roads and highways

In general, the actions listed under Land Development through Transportation Energy Conservation Information attempt to reduce the need for transportation. Those actions listed under Mass Transit through to Bicycles and Pedestrians accept the transportation need but attempt to divert the traveller

from the automobile to more energy efficient modes. Finally, the remaining set of actions recognize the need for transportation through various modes, including automobiles, but attempt to find ways in which it could be done more efficiently.

This Chapter concludes with some observations regarding the more promising energy conservation actions. It is these actions which will form the basis of some alternative transportation energy conservation strategies, one of which will be evaluated in the demonstration project.

Land Development

This set of actions attempts to reduce the need for transportation by influencing and restricting residential, industrial and recreational development. The objective of the influence and restrictions is to bring together housing, employment, services and recreation, processes which Newman and Kenworthy described as "densification" and "centralization" (p. 149).[3]

Land development actions could either influence new development or result in redevelopment. New development actions include:

. Increase density of residential settlement, particularly on public transportation routes and in proximity to work/shopping centres.

. Decrease scatter of nonresidential settlement.

. Optimally locate recreational sites.

. Establish multiuse urban centres and subcentres.

. Encourage large commercial centres.

. Encourage industrial parks.

. Restructure metropolitan areas into multi-centered regional cities.

. Plan settlements so that housing, employment and community services are physically closely integrated.

Numerous methods exist to bring about these new land development actions. These methods include: regional development incentives, urban land use zoning, regional/provincial funding, control of utilities and services, streamlining of development approvals, urban design, immigration policies and public ownership of land. For the optimal location of recreational sites, in particular, Klein describes a process based on survey data for locating urban parks.[4] Sharpe analyzes the Australian situation and discusses several other planning changes.[5]

All analysts are not convinced of the potential of new land development actions. Maltby, Monteath and Lawler,[6] in particular, observe that general trends are to lower densities, that the scope is low because the number of developments are low, and that convincing cost/benefit analyses are not available. Thus, they conclude that urban growth restrictions will have very limited feasible effects and that "rearrangement of activities within existing land uses might have a more significant influence on

demand for travel" (p. 310). A final land development action therefore is to:

. Redirect growth and redevelopment of established urban areas.

The variance in potential energy savings through land development would obviously be great with the larger savings associated with very long-term changes. One estimate was provided by Voorhees and Associates who suggested "zoning" could result in 1 to 10 percent regional energy reductions (p. 60).[7] On the basis of a Calgary case study, however, Bhaltacharyya, citing a study by Morall, Sargious, and Thompson, observed:[8]

> While it was found in the long term, more expensive infrastructure changes such as developing a rationalized land use arrangement...could, individually, achieve higher levels of savings, TSM alternatives would appear to be more practical and achievable. (TSM consists of those actions that relate to improving the utilization of existing transportation facilities to accommmodate transportation demands) (p. 179).

Business and Commerce Practice

Influencing business and other commercial activities can also reduce transportation needs and hence energy consumption. Activities in this grouping include:

. Initiate Sunday store closings.

. Restrict store hours.

. Operate more, but smaller, store units.

. Provide home goods delivery.

The potential energy savings of these actions has only been estimated for the last action. Voorhees and Associates estimated that the provision of home goods delivery would result in a 0 to 1 percent regional energy savings.[9]

The relative importance of transportation energy conservation actions related to business and commerce practice appears limited. The commercial activities associated with these actions are regulated at the municipal level and would therefore be difficult to implement in a consistent manner. They would also likely be met with varying degrees of acceptance by small business. Attempts at voluntary compliance would seem the only possibility as far as these actions are concerned.

Work Activities

Another set of energy conservation actions are directed at work activities in both the private and public sectors. These actions include:

. Permit flexible working hours.

. Reduce the number of days in the work week.

. Conduct work at home.

. Substitute telecommunications for travel.

The first action works by spreading peak transportation requirements over a longer period and hence makes more efficient usage of mass transit capacities. The latter three actions simply reduce the need for transportation.

Several estimates of the energy savings potentials of these actions are available. Stuart and Hocking estimated that "staggered work hours" could reduce transportation fuel usage in Illinois by"up to 0.4%".[10] Voorhees and Associates, however, could not see any regional energy reduction.[11]

Estimates of energy savings associated with a four-day work week were much larger. Stuart and Hocking suggested a 0.4 to 2.6% reduction in Illinois transportation fuel use [12] while the range provided by Voorhees was between 1 and 6%.[13]

Substituting electronic communications for travel has been widely studied and subsequently generated several energy savings estimates. Maltby, Monteath and Lawler estimated an absolute upper maximum of 6 to 10% energy savings in the United Kingdom by a "substitution of telecommunications for 50 percent of business travel by private vehicle."[14] A more likely maximum,

however, was in the 4.2 to 4.8% range with 2% being the likely result.[15] The latter result was still high compared to that of Voorhees and Associates who estimated a range of 0 to 1.0% regional energy reduction for "communications substitutes"[16] and Stuart and Hocking who estimated 0.2% reduction in transportation fuel use in Illinois for "phone communications"[17] and "up to 0.43%"for "telecommunications".[18] Finally, and only for automobile and truck savings, Plotkin estimated a range of 15 to 25% for "land mobile radio"(p. 49).[19]

The time horizons required to implement the first three actions are relatively short with three month estimates provided by Stuart and Hocking.[20] Telecommunications substitutes for travel, however, involve technology developments and adoption, and the time factor is more likely in the 2 to 4 year range.

Even with desirable energy savings and acceptable time horizons, the potential of work-related conservation actions is unclear. All of the authors who have studied these actions acknowledge the importance of the social factors involved and the major behavioural changes which would be required. Stuart and Hocking also see major changes to business patterns and the potential of both "moderate" and "major" undesirable economic impacts.[21] Further study is required, a conclusion supported by Gartrell and Mendenhall in their teleconferencing report.[23] Further discussion and a synthesis of various papers is provided by Tyler, Elton and Cook.[24]

Nonwork Activities

Activities other than work also generate transportation needs. Transportation energy conservation actions which attempt to influence these activities include:

. Reduce discretionary travel.

. Vacation closer to home.

. Stay in one place rather than move around during vacations.

. Decrease frequency (but increase duration) of vacation trips.

. Restrict weekend use of recreational vehicles.

. Eliminate vacation trips.

The above actions vary in their intensity potential with variations in their energy savings potentials to match. Maltby, Monteath and Lawler estimated that a"reduction by 50 percent of other personal and social travel by private vehicle" in the United Kingdom would result in a 16 to 19% energy savings.[25] The elimination of vacation trips in the Washington, Oregon and and Idaho region was estimated by Dickinson to result in a 13% saving in total transportation energy.[26] These estimates, of course, relate only to the proportion of vehicle kilometers accounted for by these activities and are not estimates of what might actually occur. An estimate of this type was provided by Stuart and Hocking who estimated a 0.4% reduction in Illinois transportation fuel use with restrictions on the weekend use of recreational vehicles.[27]

The overall potential of reducing energy consumption

through these activities appears very limited. They would be difficult to enforce, would not help low income people who do not engage as much in such discretionary travel, and would certainly have adverse effects on the tourist industry proportional to their degree of success.

Transportation Energy Conservation Information

Individuals must both understand the energy situation as well as have specific ideas on how to conserve in order to positively respond to the other energy conservation actions. Thus, Habermann suggested accurate and simple information in order "to guide the consumer toward an eventual reassessment of value systems that prioritize the use of the private automobile" (p. 101).[28] Similarly, Horowitz concluded that "while incentives are required to change affect, persuasion (advertisement) is sufficient to change cognition" (Abstract page).[29] Actions which meet these objectives are:

. Provide individuals with transportation energy conservation information through advertising and direct mail.

. Provide members of public and private sector organizations with transportation energy conservation information through educational seminars.

The potential receptiveness of the public to relevant information is partially indicated in the results of a U.S. survey conducted in October 1974 by the Opinion Research Corporation.[30]

In response to the statement that the "Federal government inform on energy conservation" (p. 872), it was found that 84% were in favour. A more recent and specific indicator is provided by Rothstein who described a Midland-Odessa, Texas experiment where weekday evening television displayed graphs on daily gasoline consumption and provided conservation tips.[31] It was found that these tips and feedback through the mass media significantly reduced fuel consumption.

Information actions would serve to both reduce transportation needs as well as cause greater efficiencies. For example, Boyle cites a U.S. Office of Technology Assessment study which estimated that a major marketing effort of promotional and informational programs would result in a maximum increase in mass transportation ridership of 2 to 4%.[32]

Trip Generation and Planning

All trips, whether work or nonwork, are subject to increased efficiencies. Actions which accomplish this include:

. Audit transportation activities.

. Provide trip-planning assistance.

. Decrease trip production.

. Decrease trip length.

. Consolidate trips.

. Integrate client-agency social services.

The energy savings of these actions would show great variance although some estimates are provided by Stuart and Hocking. They noted that a "striking result" of the 1979 fuel shortage in Illinois was "the realization that a 5 to 10 percent transportation fuel shortfall can be accomplished relatively easy via such voluntary adjustments in personal travel behaviour" (p. 191).[33] At a more specific level, they estimated that trip chaining would reduce Illinois transportation fuel use by between 0.3 and 0.6% (p. 150).[34]

From a management point of view, it is important to know how travellers are modifying their trips in response to the above transportation energy conservation actions and others listed in this report. As Witkowski and Taylor stated, a program to monitor trends in consumer behavior, public perceptions and regional attitudes should be initiated.[35] Thus, the final action in this section is to:

. Monitor traveller perceptions, attitudes and behaviour.

A pertinent illustration of this action is Neveu's New York State telephone survey conducted during the Fall of 1977.[36] Attitudes towards various transportation energy conservation actions were assessed in one question with results as follows:

Action	Percent Agreement (n=454)
Incentives for carpooling	91%
Enforce 55 mph limit	91
Improve traffice flow	90
Encourage people to plan trips better	87
Encourage people to shop closer to home	82
Encourage people to shop less frequently	74
Laws limiting new car size	59
Rebates for buyers of little cars	58
Tax on new big cars	52
Ration gas to families, with certain exceptions	32
Commuter and parking taxes	26
Build more superhighways	25
Increase gas taxes through taxes	12

Such information would appear important to planners as they select and implement various actions.

Mass Transit

Modal shifts. A large number of actions are concerned with switching urban and intercity automobile travellers to mass transportation alternatives. This is done by improvements to convenience, reliability, travel time, comfort, safety and cost, service characteristics which travellers consider when making their modal choice. A first relevant subset of actions are:

. Improve transit service.

. Reduce walktime.

. Provide park-and-ride service facilities.

. Increase parking spaces at mass transit stations.

. Provide "kiss-and-ride" facilities.

. Reduce headways.

. Increase reliability.

. Improve fare-collection facilities.

. Reduce travel times.

Energy savings due to overall improvements in transit service have been estimated by Voorhees and Associates to be 1 to 3 percent regional energy reduction for "service improvements,"[37] by Rowe and Glenn to be 0 to 2 percent reduction in fuel for a 50 percent "improvement of transit service" with "headway reduction, etc.",[38] by Boyle to be 0.06 percent (12 million litres) of the total New York 1977 gasoline consumption for "transit amenities" and 0.01 percent for "routing and scheduling improvements"[39] and by Rowe and Glenn in a review of other studies to be between 2 and 7 percent reduction in fuel for "upgrading transit system."[40]

Energy savings estimates are also available for some of the more specific actions mentioned above. Park-and-ride facilities, studied by Abdus-Samad and Grecco,[41] Brown,[42] Miller and Macqueen,[43] Schoon[44] and others, was estimated by Stuart and Hocking to lead to a 0.02 to 0.06 percent reduction in Illinois transportation fuel use;[45] and by Boyle to have led to a average 1978 to 1980 annual New York gasoline savings of 0.02 percent (7.4 million litres) for "remote" and "peripheal"to Central Business District (CBD) lots.[46] Voorhees and Associates estimated a 0.5 to 2.5 percent regional energy reduction for "Park/Ride with express bus service".[47]

Srinivasan et al. used conjoint analysis in order to simultaneously study several transit improvements.[48] "The incentive policies of reductions in headways, in walk times, and in the variabilities of excess ride time for transit were ineffective... Of the effective policies, the results suggest that 100% reductions in fares or in excess ride times for transit would be necessary to induce enough respondents to shift to transit to conserve about 6-7% of the total base line fuel consumption." However, even the latter actions were not as effective as the disincentives of fuel and parking price increases.

A final relevant estimate concerns improved fare collection procedures. Boyle estimated that "uniticket program, transfer actions, fare-structure modifications" resulted in only a 0.006% percent (1.5 million litres) reduction in 1978 to 1980 average gasoline consumption in New York State.[49]

Translation of the service characteristics named in the preceding mass transit modal shift actions leads to another subset of actions as follows:

. Provide express bus service.

. Provide shuttle-bus service.

. Provide transit service to recreational sites.

Mark, Ho and Papacostas described how a Honolulu express bus service gained increased ridership.[50] However, when Boyle took the analysis a step further and estimated net energy usage, he found an average 1978-80 annual gasoline loss in New York State of -0.6 million litres.[51] The reason was that the energy costs of the increased vehicle kilometres travelled (VKT) was greater than the energy savings due to the modal shift.

Boyle also estimated the annual average savings for shuttle bus service to peripheal parking lots for the CBD, activity centre links, and circulation within the CBD.[52] The result was a very modest 0.001 percent (150,000 litres) of the total and an estimate also verys sensitive to increased VKT.

A "public carrier for recreational travel" was estimated to have an energy savings potential of 0.2 to 0.9 percent reduction in transportation fuel use by Stuart and Hocking.[53] They observed, however, that it could have a major impact if tied to incentives (e.g. campsite reservations).[54]

Fare adjustments provide another subset of mass transit modal shift conservation actions. These include:

. Reduce transit fares.

. Reduce off-peak fares.

. Provide fare-free transit services.

. Provide transit incentives.

Reduced fares can certainly impact upon ridership such as found in a 67 percent increase in riders in a Denver non-peak fare free service.[55] However, the estimates of net savings show great variance. Fare reductions were estimated by Voorhees and Associates to have a 4 to 6 percent regional energy reduction[56] and by Rowe and Glenn to have a 0 to 3 percent fuel savings (referring to "other studies").[57] As mentioned earlier, Srinivasan et al.'s estimate for a 100 percent fare reduction was a 6 to 7 percent reduction in total fuel consumption.[58] However, McGillivray and Kemp observed that fare-free transit services "are a very costly way of achieving those shifts when they do occur" (p.353).[59]

A novel alternative to fare reductions was investigated by Deslauriers and Everett.[60] In their experiment, they found that merchandise tokens provided on both a continuous and intermittent basis increased campus bus ridership.

Mass transit modal shift actions are not limited to urban travel. Some specific intercity actions include:

. Expand automobile rail service.

. Shift short-trip aircraft passengers to bus/rail.

. Increase passenger aircraft load factors.

. Expand "fly-and-drive" services.

Orski estimated that both the automobile rail and fly-and-drive services would lead to a greater than 50 percent saving in single-businessman fuel requirements.[61] Shifting one-half

of all airplane hops under 200 miles to buses was considered by Pilati (p. 440) to be able to conserve 6.1 percent of airplane fuel.[62] Increasing passenger aircraft load factors to a practical, five year limit of 70 percent was estimated by Rubin and Hornig to be able to save 3.5 percent of total transportation fuel; a practical, fifteen year limit of 75 percent would save 6.2 percent.[63]

A final subset of mass transit modal shift conservation actions are concerned with information provision and promotion as follows:

. Improve passenger information services.

.Promote transit systems.

Energy savings from an improved information service, considered by Stuart and Hocking to be an "essential step" in a conservation program,[64] was considered by Boyle to have resulted in an average annual New York State fuel savings of 3.5 million litres (signs, map revisions, etc.).[65] In contrast, promotion (promotional advertising campaigns, tie-ins with local merchants, barter arrangements) led to 8.3 million litres savings. While the latter result is very promising, Boyle cautions that a slight increase in redership is always observed with transit promotions and publicization,but that it is always a short-term effect.[66] The implication is that such efforts must be continuous.

A number of estimates have been made of the energy savings of an increased use of and switching to mass transit by travellers i.e. the collective results of all of the mass transit modal shift actions listed in this section. The urban energy savings potential

of mass transit is indicated by a shift of 50 percent of commuters: a 2 percent fuel saving for a dedicated bus service to and from city centres by Malliaris and Strombotne;[67] a 2.7 percent saving in total transportation energy by a "shift to mass transit" by Carrier;[68] an 8 to 12 percent energy savings for a "transfer of 50 percent of urban work trips by private vehicle to bus services" in the United Kingdom by Maltby, Monteath and Lawler;[69] and a 9.5 percent regional (Washington, Oregon, Idaho) energy saving with a 20 percent load factor (16.0 percent with a 100 percent load factor) by Dickinson.[70]

Urban energy savings estimates which take into account the actual shift which might occur include: a 5 percent fuel saving by French for "a doubling of transit usage based on a switch from cars at 20 passenger-miles per gallon (14.1 L/100 km) to buses at 50 passenger-miles (5.6 L/100 km)";[71] "about 2 percent by 1990" by Kahn;[72] a "practical, 15 year" total transportation fuel saving of 1.7 percent by Rubin and Hornig;[73] a reduction of 0.3 to 0.6 percent of Illinois transportation fuel by Stuart and Hocking;[74] and a 3.1 percent saving of total energy consumed by transit, excluding demand-responsive services, in eight New York State urban areas by Boyle.[75]

For intercity transportation, the 50 percent shift potential estimates include: 2.9 percent of total transportation fuel for "auto (greater than 50 miles (80 km)) to bus/rail" by Rubin and Hornig;[76] 2.5 percent by Carrier;[77] 6.2 percent (37 percent rail and 46 percent bus load factors) and 11.0 percent (100 percent load factors) of Washington, Oregon and Idaho regional energy by

Dickinson;[78] and a 3.2 percent of fuel consumption by Malliaris and Strombotne.[79]

The realism of 50 percent shift potentials is questioned by Malliaris and Strombotne who observe that such an intercity shift would mean a 6-fold increase in intercity bus service and a 25-fold increase in intercity train service.[80] A"practical, 15 year limit" with a 20 percent diversion was estimated by Rubin and Hornig to be 1.3 percent of total transportation fuel and a "practical, 5 year limit" with a 6 percent diversion to be 0.5 percent.[81]

The latter "practical" estimates suggest that the energy savings potential of modal shifts by travellers to mass transit is very limited, a conclusion reached by Hirst and Stuntz,[82] Lave,[83] Maltby, Monteath and Lawler,[84] and Rowe and Glenn.[85] The reasons are that the cost levels of increased transit are very high, that traveller responses are very slow, that the long-run potential is very uncertain, that known cross-elasticities of demand between urban modes appear to be very low, that people value highly the comfort, reliability, flexibility, etc. service characteristics of their private automobiles, that the energy consumed by bus (1900 kilojoules (kj)/passenger-kilometer (km) (2900 BTU/passenger-mile)) and rail rapid transit (3100 kj/km (4740 BTU/passenger-mile)) are not that much different from an energy efficient auto at 10.3 L/100 km (27.5 mpg): 2790 kj/passenger-km (4250 BTU/passenger-mile).[86] Lave's conclusion is that the "major hope for conserving transportation energy is to drop our preoccupation with public transit and, instead, to concentrate on the goal of 'civilizing' the automobile."[87] According

to Hirst and Stuntz, the automobile uses 60 percent of fuel compared to only 0.5 percent by transit.[88] Thus, the potential of an improved and expanded transit is small relative to the savings possible through measures that affect the automobile.

Capital equipment. Another set of mass transit energy conservation actions are directed at the energy efficiencies of the rolling stock and other capital equipment:

. Improve design and production of mass transit equipment.

. Encourage diesel bus transit.

. Electrify intercity trains.

. Charter school buses and taxies for mass transit.

. Modify current aircraft.

. Produce derivatives of current or new near-term aircraft.

. Design new aircraft.

The overall energy savings of "changes in public transport technology" was estimated by Maltby, Monteath and Lawler to be in the range of 0.9 to 4.0 percent.[89] The need for continual investment programs, however, was emphasized.

Specific energy savings estimates include a 3.5 percent highway fuel saving for a 10 percent improvement in "automobiles to diesel transit" by French.[90] Gobetz and LeShane concluded that the most effective near-term aircraft improvement is to modify aerodynamic features (aerodynamic cleanup, winglets, fairings, etc.).[91] This would mean a fuel savings of 3 percent by 1985 and a far-term savings of 5 percent by 2000. A long-body derivative of the L-1011, or new aircraft utilizing current technology would have a 1985 fuel economy savings of 2 percent and a 2000 savings

of 9 percent.[92] Newly-designed aircraft should have a 11% percent fuel saving by the year 2000.[93]

Operating procedures. Energy savings in mass transit can be generated by improvements to the operating procedures as follows:

- Improve transit routing.
- Monitor transit operations.
- Provide radio communications to buses.
- Increase transit driver operating procedures.
- Increase transit fuel efficiencies.
- Reduce the use of air-conditioning systems.
- Improve the maintenance of transit systems.

Boyle advocated both a real-time monitoring of specific transit situations (by two-way radio and other communications systems) as well as a broader systemwide monitoring to standardize data collection on transit operations.[94] Although he estimated that these activities in New York State in the 1978 to 1980 period resulted in an annual average net loss of 110,000 litres of gasoline (the reduced VKT was offset by the increased costs), he thought the long-term effects would be positive.

Two studies identified an optimal acceleration, coasting and braking pattern for urban rail transit. Viswanathan, Longman and Domoto reported that "the New York City Transit Authority ran idealized tests...which demonstrated an 18.4 per cent decrease in energy consumption.[95] Eash reported that increased coasting before brake application had "the most potential for improving energy consumption in rail transit."[96] Other procedures

studied by Eash were increased train length, increased distance between stations, decreased speed attained between stops, and improved track profile (e.g. reduced grades).[97] Reducing the use of air-conditioning on mass transit was estimated by Stuart and Hocking to have a 0.001 to 0.002 percent reduction in transportation fuel use in Illinois.[98]

An improved maintenance program not only makes mass transit run more efficiently but increases the life span of the capital equipment. Even though it also means increased costs, Boyle determined a 0.012 percent (1.8 million litres) savings in New York State on an annual basis over the 1978 to 1980 period.[99]

A final subset of mass transit operating procedures energy conservation actions are concerned with aircraft as follows:

. Increase air service energy efficiencies.

. Rationalize air service.

. Improve aircraft operational prcedures.

. Increase aircraft load factors.

. Reduce aircraft cruise speeds by 0.02 Mach.

. Increase cruise altitude by 2000 feet (609 metres).

. Reduce the number of engines in operation of the ground.

. Tow airplanes on the ground.

Gobetz and LeShane observed that improved aircraft operational procedures, in conjunction with an improved air traffice control system, could achieve a significant 4.5 percent increase in fuel efficiency.[100] However, the absolute saving is only slightly greater than 1 percent because of increased travel. Pilati estimated that an increased load factor would conserve 15.9 percent of airplane fuel; the others ranged between 1 and 3 percent.[101]

Ridesharing and Paratransit

Modal shifts. As opposed to the large capacity, fixed route mass transit services discussed in the previous section, this section is concerned with the more flexible and lower capacity transportation alternatives known as ridesharing and paratransit. A number of transportation energy conservation actions have been proposed to shift travellers from single-occupancy automobiles to these multiple-occupancy alternatives. A subset of these actions concerned with ridesharing include:

. Encourage ridesharing for work trips.

. Encourage ridesharing for non-work trips.

. Encourage the formation of carpools/vanpools.

. Encourage the formation of carpools.

. Encourage the formation of vanpools.

. Encourage employer-sponsored vanpools.

. Encourage union-sponsored vanpools.

. Encourage pay-and-ride carpools.

. Provide incentives for carpools/vanpools.

. Provide preferential parking for carpools/vanpools.

. Build carpool/vanpool parking lots.

. Provide priority treatment on roads for high occupancy vehicles (HOV).

. Provide graduated tolls for HOV.

. Provide graduated parking fees for HOV.

. Provide commuter brokerage facilities for carpools/vanpools.

. Subsidize ridesharing programs.

. Promote ridesharing programs.

Various estimates have been made of the energy savings of these ridesharing actions. Stuart and Hocking calculated that increased use of carpools/vanpools and development of neighbourhood nonwork ridesharing would each reduce Illinois transportation fuel use by 0.6 percent.[102] Voorhees and Associates determined a range of 0 to 1 percent regional energy reduction for a neighbourhood ridesharing program[103] while French estimated that "an increase in average occupancy from 2.0 to 3.0 persons per vehicle for all trip purposes would reduce automobile fuel needs by 33 percent.[104]

For carpools, a 50 percent shift of urban commuters to this alternative was estimated by Malliaris and Strombotne to result in a 3.3 percent saving in fuel consumption[105] and by Carrier (citing Hustad) to mean a 2.4 percent conservation of total transportation energy.[106] Rubin, Pollard and Hornig considered that an ultimate limit of 3.0 passengers would mean a 10 percent saving of total transit fuel.[107]

Realistic estimates for carpools include a 3 percent saving of total fuel by Rubin, Pollard and Hornig for 1.6 passengers,[108] a 0.2 to 1.8 percent reduction in Illinois transportation fuel use by Stuart and Hocking,[109] and a 5.2 percent highway fuel saving by French for a 10 percent improvement in "increased car occupancy."[110]

Other related estimates include a reduction in Illinois transportation fuel use of 0.6 percent by Stuart and Hocking for an employer-sponsored carpool,[111] a 4 to 6 percent regional energy reduction by Voorhees for "carpool incentives,"[112] and a 2 to 4 percent reduction by Voorhees for "carpool public infor-

mation.[113]

Vanpool savings estimates range from a "negligible energy savings by 1980 in New York" (the lowest of five programs in a New York plan)[113] to "vanpools save a significant amount of fuel. In Texas the 17 400 L/year per van saving is enough to justify preferential treatment in fuel allocation."[114] Another estimate of 0.6 percent reduction in transportation fuel use was provided by Stuart and Hocking[115] with further analysis and discussion provided by Derrick, Stathalis and Kowansky,[116] Dever,[117] Gordon and Theobald,[118] Valk,[119] and Wartick.[120]

Carpool brokerage programs or activities that through computer files and other devices match up drivers and riders have received attention by Abkowitz and Ctt[121] and others. Although Voorhees estimated that a "carpool matching program" has a 3 to 6 percent regional energy reduction potential,[122] actual experience reported by Scheiner and Keiper,[123] Shu and Glazer,[124] and Stuart and Hocking[125] indicates that actual carpool formation due to brokerage services is very low.

Other relevant ridesharing energy savings estimates are a 0.03 to 0.06 percent reduction in Illinois transportation fuel use for preferential parking for multiple-occupancy vehicles[126] and a 0 to 3 percent range for the subsidization of ridesharing.[127]

Pay-and-ride carpool programs are discussed by Hoel[128] and Mohan and Schrader.[129] Instead of a fixed passenger list, a driver goes to a pickup facility to collect properly-identified potential passengers. No energy savings estimates are provided, however.

Overall evaluations of ridesharing programs are at best

mixed. Orski implies that they can work if there are strong time-savings incentives in terms of HOV lanes, reduced tolls, parking rates, etc. Gwilliam and Banister conclude that at least they are better than negative policies which restrain automobile usage.[130] However, McGillivray and Kemp see the difficulties of cooperative arrangements and even the potential of energy inefficiencies in picking everyone up.[131] Atherton, Suhrbier and Jessiman identify the possibility that any success on the work trip could be offset by increased nonwork travel due to increased automobile availability.[132] Finally, Bonsall observes that "results of recent research and experiments have shown that the impact of organized car sharing schemes will, typically, be very small and that the only impact of substance is an abstraction of patronage from public transport."[133] He concludes that "the indiscriminate encouragement of car sharing or car sharing schemes is thus unlikely to be beneficial to the transport system as a whole."[134]

A final subset of ridesharing and paratransit modal shift actions is concerned with shifting travellers to multiple-occupancy services provided by either private or public sector organizations:

. Implement demand-responsive services (dial-a-ride).

. Permit jitney services.

. Develop shared-ride taxi services.

The theoretical estimate of a 0 to 1 percent regional energy reduction by Voorhees for a "demand-responsive service" can be compared to Stuart and Hocking's observation that it uses

more energy than is saved[136] and Boyle's calculation that dial-a-bus operations and services for the elderly and handicapped cost New York State an average annual 3.8 million litres of gasoline during the 1978 to 1980 period.[137] Hoel states that they can be efficient only"when the number of demands per square mile per hour is twenty or greater[138] and McGillivray and Kemp where passenger loads are low relative to the buses.[139] Additional discussion of paratransit services is provided by Arrillaga,[140] Carlson and McShane,[141] Roos and Alschuler,[142] and Wegmann and Wiersig.[143] Teal, Marks and Goodhue analyze a recent California experience with shared-ride taxi services[144] and Hoel discusses a jitney service ("a shared taxi that operates either along a fixed route or randomly throughout a community").[145]

Capital Equipment & Operating procedures. Paratransit and ridesharing alternatives would be subject to the increased efficiency potentials described earlier for mass transit and particularly for those to be described later for automobiles i.e. routing, driver procedures, maintenance, etc. However, a particular set of taxi-related actions include:

. Encourage diesel taxis.

. Improve taxi service.

. Prohibit taxi cruising.

. Restrict taxi idling.

Voorhees and Associates estimated that to "improve the efficiency of taxi service" would mean a 0.2 percent regional energy reduction[146] while Stuart and Hocking simply noted that diesel taxis are 50 percent more efficient than gasoline taxis.[147] Stuart and Hocking also thought that taxi-idling restrictions would be very difficult to enforce.[148]

Motorcycles and Mopeds

Another set of transportation energy conservation actions is directed at shifting a portion of travellers to the highly-energy efficient moped, motor-scooter and motorcycle alternatives:

. Shift travellers to mopeds and motorscooters.

. Shift travellers to motorcycles.

French estimated that a 10 percent improvement in "automobiles to motorcycles" would result in a 4.5 percent fuel savings.[149] Canadian climatic variations, however, would create some limitations to this action.

Bicycles and Pedestrians

Actions which shift travellers from their automobiles to non-fuel consuming, human-powered alternatives provide another set of promising transportation energy conservation actions:

. Increase the number or walking trips.

. Provide better pedestrian facilities.

. Increase the use of bicycles.

. Provide bikeways and other facilities.

. Promote bicycling and walking.

. Permit organized hitch-hiking.

Carrier, citing Hustad, stated that if it was possible to "get 50 percent of people to walk up to 2 miles," it would mean a 1.8 percent conservation of total transportation energy.[150] Regional energy reduction potentials provided by Voorhees and Associates were: 0.5 to 2.5 percent for "pedestrian malls," 0 to 0.5 percent for "pedestrian-actuated signals," and 0 to 0.5

percent for "second-level sidewalks."[151]

Moran provides the definitive study on the substitution of bicycles for automobile travel in order to conserve energy.[152] She estimated that if it was possible to raise the current U.S. level of bicycle commuters from 470,000 (1975) to between 1 and 2 million by 1985, it would mean a fuel savings "in the range of 16 to 24 million barrels per year."[153] Her paper includes an exhaustive discussion and list of the actions necessary to reach the 1985 bicycle commuter target. Coleman provides further discussion and emphasizes the need for public authorities to act first to provide facilities as opposed to waiting for the number of cyclists to increase.[154]

Other bicycle-related energy savings estimates include bikeways for which Voorhees and Associates provided a 0.5 to 2.0 percent regional energy reduction potential[155] and Stuart and Hocking an "up to 0.2 percent" reduction in transportation fuel use in Illinois.[156] Voorhees and Associates added a 0 to 1.0 percent regional energy reduction for "bikeway storage facilities" and a 0 to 0.5 percent range for "bicycle priority regulations at intersections."[157]

Organized hitch-hiking, as much a ridesharing action as a pedestrian action, was discussed by Hoel who describes a Marin County, California program.[158]

Various energy savings estimates are provided for overall shifts of travellers to human-powered modes. French estimated that "if 8 percent of auto trips, or half of trips 5 miles or less, could be eliminated" and walked or bicycled, it would mean

an 8 percent fuel saving.[159] A 10 percent improvement in "school bus riders to walk and bicycle" would mean a 0.03 percent highway fuel saving.[160] Stuart and Hocking estimated a 0.3 to 0.5 percent reduction in Illinois transportation fuel use for non-motorized travel,[161] Maltby, Monteath and Lawler a maximum of approximately 1 percent for "provision of cycle facilities and pedestrianization,"[162] Rubin, Pollard and Hornig a "practical, 5 year" limit of 0.5 percent of total transportation fuel and a 15 year limit of 0.9 percent,[163] and Dickinson a 0.7 percent Idaho, Oregon and Washington regional energy reduction by switching 2 out of 3 short automobile trips to human-powered modes.[164]

The amount of travel that could be substituted for by bicycles and walking is perhaps relatively small, particularly in Canada, and there are costs associated with any new bicycle or pedestrian facilities. However, there are added health benefits as well as a potential to help sensitize the public toward energy conservation. This set of actions might best be part of a larger program.

Automobiles

Manufacturing and sales. At least in the near-term, it is not possible to shift urban and intercity travellers to mass transit, paratransit, ridesharing and human-powered alternatives. In addition, the automobile consumes a very large, 60 percent proportion of total transportation fuel.[165] Thus, a very important set of transportation energy conservation actions are directed at increasing the manufacturing and sales of energy efficient automobiles. A first subset of these actions attempts to influence

the overall production:

. Encourage new energy-efficient automotive technology.

. Improve vehicle design.

. Improve aerodynamic design of automobiles.

. Reduce automobile size and wight.

. Implement production and importation ceilings re sizes and configurations of automobiles and their power plants.

. Provide accelerated depreciation of new capital equipment needed to produce more efficient vehicles.

. Provide tax credits to manufacturers on sales of new (more efficient) vehicles and components.

. Set standards re weight, engine size and displacement, and fuel economy.

Improved aerodynamic design is a promising area. According to McGillivray and Kemp, the Transportation Energy Panel (1972) estimated a 5 percent energy saving to be easily achievable and a 20 percent improvement at a slight additional cost and with some retooling.[166] Malliaris and Strombotne cited a 3 to 5 percent savings for a "non-major redesign of the autombile body".[167] Chrysler engineers said that every 10 percent reduction in wind drag raises fuel economy by 2 percent.[168]

According to Orski, weight is the single most important parameter which influences fuel economy.[169] He cited studies which show that an increase of 100 pounds (91 kg) leads to a fuel economy loss of 1 to 2 percent.[170] Weight reductions could be achieved through elimination of less essential vehicle features and substitution of lighter components (e.g. aluminum, magnesium,

high-strength low-alloy steel, fibre-reinforced plastics, etc.)

Another subset of automobile manufacturing energy conservation actions concern the engine:

. Increase engine energy efficiency.

. Develop more energy-efficient unconventional engines.

. Develop non-petroleum based propulsion systems.

. Selectively remove pollution control devices.

Engine energy efficiency can be improved with changes such as "improvements in ignition, air induction, carburetion and fuel injection"[171] (a 5 to 15 percent savings), a "smaller engine with a power booster for acceleration" (a 10 to 15 percent savings),[172] a "smaller engine with an infinitely variable transmission" (a 10 to 15 percent savings),[173] a "lean mixture engine" (a 15 to 20 percent savings),[174] and energy-storing flywheels ("could potentially boost fuel efficiency (of internal combustion engines) by as much as 65%".[175] Increased compression ratios, increased use of electronic engine-control systems, turbo-charging, better combusion-chamber design, more efficient torque converters and the reintroduction of overdrive are further possibilities.

Substituting more efficient, unconventional engines is another possibility. The diesel is probably the most well-known alternative and has energy-savings estimates of "25% improvement" from Dallaire[176] and a 5 to 10 percent, and possibly more energy savings, from Maltby, Monteath and Lawler.[177] Other possibilities include the stratified charge engine ("prototypes...show a 15 to 20 improvement in fuel economy"),[178] the Brayton-cycle or gas turbine

(a 20 to 30 percent improvement),[179] the Stirling cycle engine (a "30 percent improvement hope";[180] "ability to conserve and side effects not known")[181] and the Rankin (steam) engine.

The electric engine is apparently twice as efficient in transforming raw fuels to automobile wheels as the conventional engine. However, their low power to weight ratio and limited speed and range make them unadvantageous for use in heavy vehicles or in vehicles to be used for many long trips. Although their conclusion may now be dated, McGillivray and Kemp concluded that "not enough is presently known about the performance and costs of alternative configurations to make informed choices."[182]

A focus upon fuels provides another set of automobile conservation actions:

- Increase fuel efficiency.
- Subsidize the development of fuel-saving innovations.
- Implement mandatory fuel efficiency standards.
- Develop substitutes for petroleum fuels.

Emerson and Walton cite the U.S. Senate-passed minimum mileage standards which rise from 16 mpg (17.6 L/100 km) in 1980 to 21 mpg (13.5 L/100 km) in 1985.[183] Estimated fuel savings are small because "the minimums are applied at a miles per gallon level which effects only a few cars."[184] Although the standards could be increased, Cardell and Dunbar conclude from their analysis that "gasoline taxes are a more effective instrument for reducing oil inputs than are auto industry regulations."[185]

Alternative fuels to petroleum include liquid methane, methanol, propane, ethanol and hydrogen.[186] According to McGillivray and Kemp, the best alternatives are ethanol and propane, with methanol and liquid methane appearing acceptable.[187] Partly because of the required heavy tanks and restricted distribution, however, they feel "that none of them appear likely to account for a large share of the automobile fuel market in the near future."[188]

A final subset of automobile manufacturing actions are concerned with improvements outside of the overall design and powerplant:

. Improve non-engine operating efficiencies.

. Eliminate unnecessary convenience devices.

Estimates for using radial tires are in the 3 to 10 percent[189] and 5 to 10 percent range.[190] Chrysler's "lock-up torque converter" is estimated to achieve 2 percent fuel economy improvements in the city and 6 percent in highway driving[191] while Borg-Warner's new transmission should yield a 20 percent savings.[192] Other improvements are "auto accessories driven at a constant rate" (3 to 8 percent savings),[193] lower axle ratios, and conversion from automatic to standard transmission.[194]

The preceding automobile conservation actions attempt to directly influence the manufacturing process. An alternative approach is to indirectly influence this process by dealing with the consumer or purchaser as follows:

. Speed purchase of more energy-efficient cars.

. Provide tax rebates or credits against income tax for the purchase of fuel-efficient vehicles.

. Subsidize the purchase of fuel-efficient vehicles.

. Implement differential fuel-efficiency taxes.

. Provide preferential interest rates for loans used in the purchase of new, fuel-efficient vehicles.

. Implement graduated annual registration fees.

. Implement graduated taxes depending upon the engine size.

. Provide for accelerated depreciation in the purchase of fuel-efficient vehicles.

. Publish fuel efficiencies.

. Implement mandatory "truth-in-labeling" energy consumption disclosures.

. Provide "bounty payments" for trade-ins of operable "gas guzzlers".

. Teach buyers to look at life-cycle cost instead of initial vehicle cost.

. Give away mini-cars to commuters and permit only mini-cars on highways during rush hours.

Although likely to be very controversial, "gasoline guzzler taxes" have received much attention. Stuart and Hocking estimated a 5.4 percent reduction in Illinois transportation fuel use,[195] Rowe and Glen a 5 to 7 percent reduction in fuel,[196] and Emerson and Walton a 0 to 2.5 percent reduction in total 1985 fuel con-

sumption depending upon the degradation between in-road and Environmental Protection Agency (EPA) tests.[197]

Other energy-savings estimates provided are: a graduated tax depending upon car engine size ("perhaps about 2%, up to 8%");[198] bounty payments for trade-ins of operable, fuel inefficient vehicles (some 500 gallons (2273 L) for a car with 10 mpg (28.2 L/100 km) otherwise driven 10000 miles (16 090 km), scrapped and replaced with a 20 mpg (14.1 L/100 km) vehicle);[199] and giving 28 mpg (10.1 L/100 km) mini-cars to commuters to replace their 12 mpg (23.5 L/100 km) average cars (a 4 percent savings).[200]

The result of a successful implementation of the automobile manufacturing energy conservation actions will be a fleet of more energy efficient vehicles & numerous estimates have been made of the energy savings. They include: 9.5 percent of the total 1970 transportation energy expenditure for conversion of 50 percent of passenger cars to small cars with 22 mpg (12.8 L/100 km);[201] 12 percent of total transportation energy consumed for a 50 percent conversion to fuel economic cars;[202] 5 to 10 percent for vehicle efficiency adjustments;[203] 6.4 percent highway fuel savings for a 10 percent improvement;[204] 21 to 24 percent energy savings in the United Kingdom for a one-third improvement in petrol consumption;[205] 15.3 percent of total transportation fuel for a "practical, 15 year limit, 20 mpg (14.1 L/100 km) fleet average;[206] a 34 percent energy savings for a 20.82 composite mpg (13.5 L/100 km) vs. the 1971 13.61 mpg (20.7 L/100 km) composite in the Washington, Oregon and Idaho region;[207] and a 40 percent

reduction in automobile fuel use for a 70 percent improvement in production weighted mpg by 1985 (12.3 L/100 km).[208]

As the above energy savings estimates consistently indicate, the fuel consumption decreases for an energy-efficient automobile fleet are relatively large,and greater than the savings estimated for the other actions (and particularly the public transit actions). This conclusion has been reached by a number of other analysts including Carrier,[209] Maltby, Monteath and Lawler[210] and others.

Operating procedures. This subset of automobile conservation actions deals with operating efficiencies as follows:

- Improve vehicle maintenance.
- Subsidize automobile tune-ups.
- Provide voluntary inspection facilities.
- Implement mandatory vehicle inspections.
- Improve driving habits.
- Encourage the use of MPG (L/100 km) meters.
- Reduce air conditioning usage.

According to Orski, an improperly tuned engine penalizes energy consumption as much as 6 percent; a poorly maintained ignition system as much as 20 percent.[211] Thus, the average improvement from a tune up is 5.3 percent increase in fuel efficiency;[212] "having the car tuned" a 3 to 9 percent savings;[213] and a maintenance program a 2 percent reduction in Houston[214] and a 0.2 to 0.5 percent reduction in transportation fuel use in Illinois.[215] Keeping tires inflated is important because each pound of underinflation means

a 2 percent fuel loss.[216] Using low friction oils and keeping the engine oil filter clean are also important.

Carey and Larocca provide useful information from the New York experience with vehicle inspections.[217] Annual inspections in the N.Y. City metro area resulted in an average reduction in fuel use of 10 percent for each car that failed the initial inspection.[218] It was considered to have saved 6.2 trillion BTU (6.5 trillion kj), the third most effective program of five programs.

According to Milstein, improved driving habits can mean 20 percent greater fuel consumption compared to the average driver and 50 percent more than the wasteful driver.[219] Improved driving would mean smooth and moderate acceleration, driving at a steady pace, avoiding stop and go traffic, minimizing braking, not letting the motor idle for more than a minute, not overfilling the gasoline tank and removing unnecessary weight from the car. Providing drivers with MPG (L/100km) meters, however, has not so far been successful.[220]

According to Orski, air conditioning penalizes energy consumption by between 9 and 20 percent depending upon the weather.[221] Thus, Stuart and Hocking estimated a 0.2 to 0.4 percent reduction in transportation fuel use in Illinois by reductions in their use.[222]

Vehicle usage restrictions. This final set of automobile conservation actions is directed at vehicle usage. By making their acquisition and usage more difficult and inconvenient, travellers will presumably be diverted to the transit, multiple occupancy

and human-powered alternatives described above. These vehicle resriction actions include:

. Increase the qualifications for drivers licenses (e.g. increased age).

. Increase vehicle fees.

. Implement graduated registration fees for multiple automobiles.

. Restrict parking spaces.

. Reduce parking areas.

. Increase the parking charges.

. Institute a parking tax.

. Increase time-of-day rates.

. Establish automobile-restricted zones.

. Implement automobile congestion tolls.

. Introduce no-drive days.

Increasing the minimum driving age could reduce Illinois transportation fuel use by 0.6 percent according to Stuart and Hocking.[223] However, they also acknowledged that it could have a "major" undesirable economic impact by retarding employment and the activities of drive-ins and other auto-oriented business.[224] Estimates of other acquistion restrictions include a 2 to 10 percent regional energy reduction for "vehicle-related fees"[225] and a 0.3 to 0.6 percent reduction in Illinois transportation fuel use for graduated registration fees.[226]

Placing restrictions on parking has received some attention and various estimates have been made of their effectiveness. Voorhees and Associates estimated a 0.5 to 3.0 percent regional energy reduction for "increased parking costs"[227] while Srinivasan et al. found it to be the most effective action in a conjoint analysis of several conservation actions.[228] Stuart and Hocking's estimate for Illinois transportation fuel use was a 1.4 to 1.9 percent reduction for a parking tax.[229] Although Maltby, Monteath and Lawler estimated a 1 percent effectiveness for "higher...standing charges," they saw it as inequitable and subject to substantial opposition.[230]

The introduction of one carless day per week was identified by Stuart and Hocking as having a reduction in Illinois transportation fuel use of 6 percent.[231] However, they also identified a "moderate" undesirable economic impact and that it would likely to be unpopular with the motoring public.[232]

A fairly consistent pattern among these automobile restriction actions was a reasonable energy savings potential. Also consistent, however, was their potential not only to restrict travellers but also to restrict economic and business activity. Public opposition could be considerable. Gwilliam and Banister concluded that positive attempts to increase vehicle occupancy at the peak are likely to be more favourable to public transport finances than the more negative policies to restrain use of the car for the journey to work, or second car ownership.[233]

Fuels

Automobile travel can also be influenced by altering the supply of and demand for fuel. The applicable conservation actions include:

- Decrease fuel supply.
- Implement weekend closing of fuel outlets.
- Implement mandatory fuel outlet allocations.
- Implement limits on fuel imports.
- Implement limits on fuel production.
- Implement mandatory regional allocations.
- Restrict fuel outlet opening hours.
- Restrict purchases of fuel.
- Implement mandatory purchase limits on volume/amounts.
- Restrict sales by license plate digits.
- Implement purchase restrictions by odd/even days.
- Ration fuel.
- Increase fuel prices.
- Encourage 3 gallons less per week per vehicle.

Energy conservation estimates of some of the restrictive measures include a 2 to 10 percent regional energy reduction for a "ban on Sunday and/or Saturday gas sales"[234] and a 5 to 20 percent regional energy reduction for a "restriction of quantity of sales on a geographic basis".[235] Other measures, however, can be inefficient when they force travellers to make repeated small

purchases, travel to more than one station, wait in line, etc. Equity problems are also created and fuel outlets are given discretionary powers which can be abused.

Fuel rationing, both with and without transferable coupons, has received some attention. The effects, of course, can be controlled with a range of 10 to 25 percent regional energy reduction provided by Voorhees and Associates.[236] There may also be side effects which Corsi and Harvey found in a survey where respondents indicated that gasoline rationing would have a far more substantial impact on their mode choice for travel to work than would a price increase of $0.05/L.[237] Rationing, however, is administratively cumbersome, has undesirable economic effects and creates equity problems.[238] Lee[239] and Rowe and Glenn[240] provide further discussion.

Increasing the price of fuel, through either a tax or allowing it to reach market levels, is extremely well-studied. A gasoline tax would reduce Illinois transportation fuel use by 1.1 to 2.3 percent[241] according to Stuart and Hocking and a regional energy reduction of 2 to 6 percent according to Voorhees and Associates.[242] Srinivasan et al. estimated a 7 percent gasoline savings for a 50¢ surcharge on gasoline and found it especially effective with parking charge increases.[243] Estimates for a 25 percent price increase are 2.7 to 9.0 percent in the United Kingdom[244] and 5 percent in Houston.[245] A 50 percent price increase had estimates of 5.5 to 18.0 percent[246] and 9 percent[247] for the same areas Barnaby and Reizenstein surveyed consumers and

asked about 5¢ per gallon increases.[248] They concluded that "A large proportion of the population will respond both initially and on a continuing basis to price increases to foster a substantial decrease in gasoline consumption."[249]

The issue of how the public responds to fuel price increases centers on price elasticities and the magnitude of the change. Some, such as Orski believe gasoline could be very price inelastic (e.g. -0.4 to -0.2)[250] and that "moderate and gradual increases in fuel prices are unlikely to cause significant modifications in household travel patterns."[251] However, the discrepancy of these results with the preceding are probably explained by Mehring who derived price elasticities for gasoline, jet and diesel fuels in the short and long run.[252] He concluded that "in the long run, significant response in gasoline and jet fuel consumption could result from fuel price increases... but fairly small elasticities in the short run."[253] Resolution of the point is very important because a mistaken attempt to force conservation on the assumption of high elasticities when they are in fact low could result in little energy savings and an undesirable economic impact and regressive impacts on low income groups[254] as well as increased inflation, decreased productivity and international competitiveness and perhaps even decreases in the standard of living.[255] Further discussion is provided by McGillivray and Kemp,[256] Kahn,[257] Tait and Morgan,[258] and Gobetz and LeShane.[259]

Roads and Highways

Development and construction. The roads and highways that travellers use can also be examined for energy savings potentials. This first subset of actions gets at the engineering and design:

- Provide adequate arterial and expressway capacity.
- Construct urban area bypass routes.
- Reduce grades.
- Improve road surfaces.
- Build HOV lanes and ramps.

Under typical urban conditions, fuel consumption is 30 to 40 percent higher than on the open road.[260] Broken pavement causes a 50 percent increase in additional fuel consumption[261] and for grades greater than 6 percent, the extra upgrade fuel exceeds the downhill fuel savings.[262] Thus, attempts to emulate the open road, improve surfaces and reduce grades will have energy savings possibilities. French estimated a 6 percent fuel saving "if construction improvements, particularly arterial grade separations and progressive signal systems, could improve rush hours mpg by one third," and "at least 10% should be achievable" from"efforts to flatten grades, enforce speed limits, reduce travel distances, and maintain pavements."[263]

High occupancy vehicle (HOV) lanes and ramps have received considerable attention because of their potential to both speed up mass transit as well as offer incentives to high-occupancy

vehicles. Energy savings estimates are 0.6 to 1.8 percent reduction in Illinois transportation fuel use,[264] 0 to 2 percent regional energy reduction for "bus-only lanes on city streets,"[265] 1 to 3 percent regional energy reduction for "reserved freeway bus or bus/carpool lanes and ramps"[266] and 1 to 5 percent for the same facility in urban areas of one million plus population.[267] Sheffi, however, did an "equilibrium analysis by means of logit mode-choice model and typical volume-delay curves" and concluded that "such projects (for buses) might bring about the expected benefits only under extreme congestion."[268] Rothenberg is not quite so pessimistic and asks only that there be a "significant travel time saving (10 minutes or more)"[269] and a "major reconstruction program of urban freeways and arterials to provide a physically separated, high capacity system for high occupany vehicles."[270] He also advocates contra-flow lanes, exclusive median with-flow lanes, and bypasses of metered freeway ramps.[271] Further discussion is provided by Miller and Deuser[272] and the Federal Highway Administration.[273]

Much like the automobile usage restriction actions which attempt to discourage travel or switch travellers away from the car, some have advocated making the roads and highways less attractive:

- Curtail road development.
- Reduce improvements and maintenance programs.

Some have suggested that such actions would have an associated energy savings. Maltby, Monteath and Lawler, for example, estimated that a "curtailment of road investment" would have a 5 percent maximum energy savings, and likely smaller.[274] Taber, however, examined the issue and concluded that:[275]

> "lowering highway capacity will, on balance, increase the amount of fuel consumed in urban travel because the percentage increase in fuel consumption per VMT from the resulting increase in peak-period congestion exceeds the percentage reduction in VMT's. The increase in urban highway fuel consumption from a 20% reduction in urban highway capacity is estimated to be at most 2%."

Traffic management. Existing roads and highways can be made more energy efficient in a number of ways, the first subset of actions being:

- Implement a traffic management program.
- Implement a commercial traffic management program.
- Instal a computerized traffic control system.
- Improve signals.
- Eliminate unnecessary traffic control devices.
- Instal ramp-metering devices.
- Advise drivers on traffic conditions.
- Improve traffic engineering for buses.

Citing "other studies," Rowe and Glenn estimated that "traffic management" could mean a 1 to 4 percent energy savings.[276] Other estimates are 3 percent for a "comprehensive application of state-of-the-art techniques for improved traffic control of

signalized urban arterials and freeways,"[277] "an immediate payoff of between 9 and 15 percent, although it drops to half that over time" for"improving driver behavior and traffic control,"[278] and a 1980 energy savings of 10.2 trillion BTU (10.8 trillion kj) (the second largest saving of five programs) for "traffic engineering improvements" in New York State.[279] "Commercial traffic management" was estimated by Rowe and Glenn to reduce energy consumption by 1 to 5 percent.[280]

Energy savings estimates for components of a traffic management system include: a 1 to 4 percent regional energy reduction for "improved signal systems,"[281] an 18.4 percent annual fuel reduction for "transforming the isolated independent signalized intersections into a interconnected progressive system" over a 2 km section of U.S. Route 30 in Bryn Mawr, PA.[282] up to 0.4 percent reduction in Illinois transportation fuel use for "TOPICS",[283] a 0 to 2 percent regional energy reduction for the elimination of unnecessary traffic control devices,[284] a 0 to 1 percent regional energy reduction for "ramp metering, freeway surveillance, driver advisory displays",[285] a 0 to 0.5 percent regional energy reduction for a "driver advisory system",[286] and a 0 to 0.5 regional energy reduction for both "bus-actuated signals" and "bus priority regulations at intersections."[287]

A further set of roads and highways traffic management conservation actions both add and remove traffic restrictions:

. Restrict on-street parking.

. Convert two-way to one-way street systems.

. Provide reversible lanes.

. Legalize right turns on red lights.

. Prohibit left-turns along major arterials.

Although Stuart and Hocking considered that on-street parking restrictions could reduce transportation fuel use in Illinois by "up to 0.4%,"[288] he acknowledged a "moderate" undesirable economic impact because curb parking is important to some businesses."[289] Voorhees and Associates provided a 1 to 4 percent regional energy reduction estimate for "one-way streets, reversible lanes, no on-street parking."[290]

A final subset of roads and highways traffic management conservation actions restrict usage through costs , speed limits and other restrictions:

. Charge for roads and highways usage.

. Increase licensing fees.

. Implement differential peak-hour tolls.

. Restrict road access by vehicle types.

. Implement automobile-free zones.

. Reduce speed limits.

. Enforce speed limits.

. Implement differential speed limits by vehicle type.

. Ban pleasure rides e.g. Sunday driving.

Relevant energy savings estimates here are: 1 to 5 percent regional energy reduction for both "bridge and highway tolls" and "congestion tolls and road cordon tolls" and 2 to 6 percent reduction for a "mileage tax".[291]

"Limiting freeway usage" was estimated to have a 0 to 1 percent regional energy reduction potential.[292] Other automobile restriction estimates include: 1.1 percent[293] and 1.6 percent[294] savings for eliminating 50 percent of urban and traffic congestion, o.5 to 2.5 percent[295] and 0.2 to 2.8 percent[296] for "automobile-free zones, and "negative, 0, 1" percent for "traffic constraint in urban areas."[296]

"Reduced speed limits" was estimated by Voorhees and Associates to have a 0 to 2 percent regional energy reduction potential.[297] "Reduce to 50 mph and achieve 50% success" had 3 percent[298] and 2.8 percent[299] savings estimates. An "ultimate (50 mph)" objective has a 2.9 percent saving potential[300] and an average speed in the Oregon, Washington and Idaho region a 3.8 percent saving.[301]

As might be expected, enforcing the speed limits for 50 mph had estimates of similar magnitude although those for a 55 mph limit are lower e.g. 0.3 to 0.5 percent reduction in Illinois transportation fuel use.[302] Perhaps the most interesting result was that of Carey and Larocca where it was reported that "increased enforcement of 55 mph" led to an estimated 1980 savings of 16.6 trillion BTU (17.5 trillion kj), the highest saving of five New York State conservation programs.[303]

The banning of pleasure trips is a final action with estimates of 10 percent saving of all gasoline consumption in the United States and 8 percent of the Washington, Oregon and Idaho regional consumption[305] for bans on Sunday driving. However, Orski noted that even though there were savings of 5.6 percent of monthly gas consumption in Germany, the Sunday ban had very adverse effects on recreation and tourism activities/facilities.[306]

Goods Movement

Truck manufacturing. A set of transportation conservation actions is directed at the other major user of energy - the movers of freight and other goods. The first subset are concerned with the manufacturer of fuel efficient trucks:

. Increase truck efficiency.

. Reduce truck weight.

. Increase truck aerodynamic efficiency.

. Provide provision for declutching fans.

. Dieselize trucks.

. Turbocharge diesels.

. Switch trucks to smaller engines.

. Lower axle ratios.

. Increase truck fuel efficiency.

. Use radial tires.

. Switch trucks to alternative fuel forms e.g. propane.

. Provide tax investment credits for the purchase of fuel efficient trucks.

. Provide a more rapid depreciation for the more efficient trucks.

Rubin, Pollard and Hornig estimated that "high efficiency trucks" had a "practical, 15 year" potential of 5.4 percent of total transportation fuel and a "practical, 5 year" savings of 2.2 percent.[307] To French, a 10 percent improvement in the fuel efficiency of single unit trucks would mean a 1.5 percent highway fuel saving and a 10 percent improvement in truck combination, a 0.8 percent saving.[308] Finally, as a result of a Calgary urban goods movement study, Bhaltacharyya identified "vehicle dieselization" as a"key energy conservation element".[309]

Operating procedures. A final set of goods movement conservation actions attempts to increase the operating efficiency of trucks.

- Shift freight from truck to rail.
- Use piggyback rail between urban centers.
- Increase the use of waterborne transportation.
- Combine rail freight and rail passenger operations.
- Increase/decrease truck size.
- Increase truck loading.
- Better match the load to the transport vehicle.
- Increase truck routing efficiency.
- Consolidate urban delivery of small freight shipments.
- Reduce speeds to optimum.
- Instal speed governors.
- Improve vehicle maintenance.
- Deregulate motor carriers.
- Improve driving habits.
- Ban truck idling.
- Require adequate urban truck-loadings facilities.
- Reduce number of panel trucks and pickups.
- Implement urban truck congestion restrictions.

A "shift of 50 percent of intercity trucking (trucks which travel more than 10,000 miles/year) to rail freight" has been estimated to have a 3.6 percent fuel saving potential.[310] A lower "practical, 15 year" limit was 0.64 percent of total transportation fuel and in 5 years, 0.32 percent.[311] A Canadian estimate

of CN Piggyback for 1979 revealed a savings that year of 54 million litres of fuel compared to highway trucking.[312]

Increased truck loading has received some attention and was identified as a key conservation element in a Calgary urban goods movement study.[313] Energy savings estimates include: 4.4 percent of total transportation fuel in 15 years and 3.9 percent in 5 years,[314] 1.4 percent highway fuel saving for a 10 percent increase in single truck loading,[315] and 0.7 percent for a similar increase in truck combinations.[316]

Other trucking operating procedures discussed include: improved driving habits of drivers[317] and reduction of truck traffic the CBD.[318] Of particular interest is a Charles River Associates study which estimated the fuel savings of deregulation of U.S. motor carriers.[319] The sum of a detailed list of actions was 35.4 million gallons (160.9 million L) median annual fuel savings.

One estimate of the overall savings for all of the preceding actions was 0 to 1.5 percent regional energy reduction for "improved efficiency of UGM".[320] This estimate appears low, however, given the magnitudes of the preceding more specific actions. A more likely result is provided by French who stated that "by consolidation, small diesel engines, increased size and weight, increased warehousing and other adjustments, it is judged that 1985 truck fuel consumption can be about the same as 1973."[321] Unlike automobile manufacturing and operating procedures, trucking and urban goods movement has not received a great deal of attention with respect to its energy savings. It does, however, appear deserved.

Conclusions

What types of actions deserve further study and possible implementation? At a first priority level are actions concerned with the manufacturing, sales and operations of automobiles and trucks. Manufacturing actions are longer term in nature but provide the potential for large absolute and relative levels of energy savings. The savings associated with operating procedures are not quite as large but can be much more quickly implemented.

At a second level of priority are actions concerned with informing travellers and promoting the more energy efficient alternatives. Not only have direct results been demonstrated as a consequence of these actions but they also support the other actions as well. A similar reason supports the trip planning action "Monitor the perceptions, attitudes and behaviour of travellers," which is also necessary for conservation management purposes.

A third priority level includes "further study" of work-related actions and increases in the price of fuel. The 4-day work week has significant energy savings but major behavioural changes. Increasing fuel prices is really the starting point for a number of other actions to occur but the price elasticities are in enough doubt to deserve further study.

A fourth priority area are actions related to the construction of roads and highways and traffic management. The energy savings potentials are there but significant investments are required for highway development and traffic management technology. The one exception is increased enforcement of speed limits which has both immediate and other (e.g. safety) benefits.

Not deserving priority treatment are actions devoted to shifting travellers from the automobile to mass transit, paratransit, ride sharing schemes, motorcycles and bicycles. Especially compared to the automobile, the energy consumption of these alternatives is less, and therefore subject to less total, absolute improvement. Their potential application is much more case specific ie. in the context of a particular urban or intercity transportation situation.

The remaining actions related to land development, business practice, nonwork activities, and fuels generally involve restrictions of various sorts. It is not simply that the restrictions generate public opposition that make them unattractive, but that they also result in undesirable economic consequences with widely varying estimates of the energy savings consequences. Positive incentives rather than disincentives appear to be the more likely direction in which to proceed.

Footnotes

1. See for example C. Dennis Anderson and Carman W. Cullen, "Energy Research on Consumers: A Literature Review" (London: University of Western Ontario, 1978); C. Dennis Anderson and Gordon H. G. McDougall, Conservation Energy Research: An Annotated Bibliography (Vancouver, B.C.: Behavioural Energy Research Group, University of British Columbia, 1980).

2. Some of the more comprehensive typologies include: Darwin G. Stuart and Richard J. Hocking, "Contingency Transportation Plans for Urban Areas and Their Potential Impacts," Transportation Research Record Special Report 191 (1980), pp. 145-157; Alan M. Voorhees and Associates, Inc., "Guidelines to Reduce Energy Consumption Through Transportation Actions" in Energy Primer: Selected Transportation Topics (Cambridge, MA: Office of Program Development, U.S. Department of Transportation, Transportation Systems Center, Kendall Square, Code 151, 02142, 1974), pp. 58-75; Peter G. Rowe and Carvel W. Glenn, "Alternative Actions for Achieving Energy Savings in the Transportation Sector. Summary" Report No. UMTA-TX-11-0010-81-1 (Houston, Texas 77046: Rice Center, 9 Greenway Plaza, Suite 1900, November 1980); Michael J. Munson and Rasin Kl Mufti, "Assessing the Impact of Transportation Energy Plicies on Travel Behavior: A Preliminary Approach," Transportation Research 13A (1979), pp. 407-416; Glenn Jilek and Richard Osborne, "Energy Considerations in Transportation Planning," Report No. FHWA/PL/79/017 (Washington, D.C.: Federal Highway Administration, U.S. Department of Transportation, 400 7th Street SW., 20590, March 1979).

3. Peter Newman and Jeffrey Kenworthy, "Public and Private Transport in Australian Cities: II. The Potential for Energy Conservation Through Land Use Change," Transportation Policy Decision Making 1 (1980), pp. 149-167.

4. Dennis H. Klein, "A Recreation Needs Assessment Process - An Origin-Destination Approach," Transportation Planning and Technology 5 (1979), pp.169-182.

5. R. Sharpe, "Improving Energy Efficiency in Community Land-Use-Transportation Systems," Environment and Planning A 12 (1980), pp.203-216.

6. D. Maltby, I.G. Monteath and K.A. Lawler, "The UK Surface Passenger Transport Sector: Energy Consumption and Policy Options for Conservation," Energy Policy, (December 1978), pp. 294-313.

7. Voorhees, "Guidelines," p. 60.

8. Sushil K. Bhaltacharyya, "A Framework for Urban Goods Movement Information in Canada, Volume 9," (Ottawa: TEE Consulting Services Inc. for the Urban Transportation Research Branch of Canadian Surface Transportation Administration Transport Canada, March 1979), pp. 176-183.

9. Voorhees, "Guidelines," p. 61.

10. Stuart and Hocking, "Contingency Transportation Plans," p.151.

11. Voorhees, "Guidelines," p. 59.

12. Stuart and Hocking, "Contingency," p. 151.

13. Voorhees, "Gidelines," p. 60.

14. Maltby, Monteath and Lawler, "The UK", p. 305.

15. Ibid., p. 308.

16. Voorhees, "Guidelines," p. 60.

17. Stuart and Hocking, "Contingency," p. 150.

18. Ibid., p. 151.

19. Howard A. Plotkin, "Reducing Fuel Consumption with Land Mobile Radio," Journal of Environmental Systems 6, no. 1 (1976-77), pp. 43-50.

20. Stuart and Hocking, "Contingency," p. 147.

21. Ibid.

22. Ibid., p. 152.

23. J. W. Gartrell and Nicole M. Mendenhall, Attitudes Towards Changes in Communications Technology: The Introduction of Teleconferencing, CRC Report No. 1280 (Ottawa: Communications Research Centre, Department of Communications, October 1975), p. 8.

24. Michael Tyler, Martin Elton and Angela Cook, "The Contribution of Telecommunications to the Conservation of Energy Resources," Report No. OT SP 77-17 (Washinton, D.C.: U.S. Department of Commerce, Office of Telecommunications, 1325 G Street, N.W. 20005, July 1977).

25. Maltby, Monteath and Lawler, "The UK," p. 305.

26. J. Thomas Dickinson, "Transportation and Energy Conservation in the Pacific Northwest (Pullman, Washington 99163: Physics Department and Environmental Research Center, Washington State University, Revised June 1974).

27. Stuart and Hocking, "Contingency," p. 150.

28. Jill L. Habermann, "Consumer Reactions to the 1979 Gasoline Shortage," Transportation Research Board Special Report 191 (1980), pp. 96-101.

29. Abraham D. Horowitz, "An Attitudinal Model of Carpooling Behavior" (Paper repared for presentation at the Annual Meeting of the American Psychological Association, Chicago, Illinois, August 31, 1975).

30. Harry W. O'Neill, "The Effects of Energy Availability and Costs on Consumer Attitudes and Behavior," in Advances in Consumer Research Volume 2 (Ann Arbor, Michigan: Association for Consumer Research, 1975), pp. 863-878.

31. Robert N. Rothstein, "Television Feedback Used to Modify Gasoline Consumption," Behavior Therapy 11 (1980), pp. 683-688.

32. Daniel K. Boyle, "Effects of Small-Scale Transit Improvements on Saving Energy," Transportation Research Record 761 (19), pp. 27-33.

33. Stuart and Hocking, "Contingency," p. 151.

34. Ibid., p. 150.

35. James M. Witkowski and William C. Taylor, "Urban Transportation Planning Under Energy Constraints," Transportation Research Record 707 (1979), pp. 1-5.

36. Alfred J. Neveu, "Public Opinion Survey on Energy and Transportation" (Albany, New York: Planning Research Unit, New York State Department of Transportation, December 1977).

37. Voorhees, "Guidelines," p. 60.

38. Rowe and Glenn, "Alternative Actions," p.6.

39. Boyle, "Effects," p. 29.

40. Rowe and Glenn, "Alternative Actions," p.6.

41. Usamah R. Abdus-Samad and William L. Grecco, "Sensitivity Analysis of Community Savings Due to Change-of-Mode Operations," Transportation Research Record 557 (1975), pp. 1-11.

42. Gerald R. Brown, "Influence of Park-and-Ride Factors in Modal Shift Planning," Transportation Research Record 557 (1975), pp. 12-20.

43. Gerald K. Miller and James T. McQueen, "Park-and-Ride in the Shirley Highway Corridor," Transportation Research Record 606 (1976), pp. 23-29.

44. John G. Schoon, "Park-and-Ride Planning for Energy Conservation: An Optimization Methodology,"Transportation Research Record 751 (19), pp. 31-37.

45. Stuart and Hocking, "Contingency," p. 151.

46. Boyle, "Effects," p. 29.

47. Voorhees, "Guidelines," p.60.

48. V. Srinivasan, Peter G. Flachsbart, Jarir S. Dajani and Rolfe G. Hartley, "Forecasting the Effectiveness of Work-Trip Gasoline Conservation Policies Through Conjoint Analysis," Journal of Marketing 45 (Summer 1981), pp. 157-172.

49. Boyle, "Effects," p. 30.

50. Bennett Mark, Peter H. P. Ho and C. S. Papacostas, "Express Bus Use in Honolulu: A Case Study," Transportation Research Record 606 (1976), pp. 6-11.

51. Boyle, "Effects," pp. 28-29.

52. Ibid.

53. Stuart and Hocking, "Contingency," p. 150.

54. Ibid., p. 147.

55. "Pollution Drives Denver to Buses," The Globe and Mail, 22 June 1978, p.7.

56. Voorhees, "Guidelines," p. 60.

57. Rowe and Glenn, "Alternative Actions," p. 6.

58. Srinivasan et al., "Forecasting," p. 166.

59. Robert G. McGillivray and Michael A. Kemp, "Alternative Strategies for Reducing Gasoline Consumption by Private Automobiles," Transportation Research 8 (October 1974), pp. 349-361.

60. Brian C. Deslauriers and Peter B. Everett, "Effects of Intermittent and Continuous Token Reinforcement on Bus Ridership," Journal of Applied Psychology 62, no. 4 (1977), pp. 369-375.

61. C. Kenneth Orski, "The Potential for Fuel Conservation: The Case of the Automobile," Transportation Research 8 (October 1974), pp. 247-257.

62. David A. Pilati, "Energy Use and Conservation Alternatives for Airplanes," Transportation Research 8 (October 1974), pp. 433-441.

63. David Rubin, J.K. Pollard and Chris Hornig, "Transportation Energy Conservation Options (Draft)," in Energy Primer: Selected Transportation Topics (Cambridge, MA: Office of Program Development, U.S. Department of Transportation, Transportation Systems Center,

Kendall Square, Code 151, 02142, 1974), pp. 51-57.

64. Stuart and Hocking, "Contingency," p. 147.

65. Boyle, "Effects," p. 30.

66. Ibid., p. 31.

67. A.C. Malliaris and R.L. Srombotne, "Demand for Energy by the Transportation Sector and Opportunities for Energy Conservation," in Energy Primer: Selected Transportation Topics (Cambridge, MA: Office Program Development, U.S. Department of Transportation, Transportation Systems Center, Kendall Square, Code 151, 02142, 1974), pp. 42-44.

68. Roger E. Carrier, "Energy Conservation through Urban Transportation Planning," Transportation Research 8 (1974), pp. 493-501.

69. Maltby, Monteath and Lawler, "The UK," p.305.

70. Dickinson, "Transportation," p.12.

71. Alexander French, "Transportation Energy Considerations," Transportation Engineering Journal 102 (February 1976), pp. 27-45.

72. Helen Kahn, "U.S. Paper Urges a New Approach to Saving Energy," Automotive News, 1 December 1980, pp. 1, 38.

73. Rubin and Hornig, "Transportation Energy," p. 54.

74. Stuart and Hocking, "Contingency," p. 150.

75. Boyle, "Effects," p. 30.

76. Rubin and Hornig, "Transportation Energy," p. 55.

77. Carrier, "Energy Conservation," p.495.

78. Dickinson, "Transportation," p. 12.

79. Malliaris and Strombotne, "Demand," p. 43.

80. Ibid.

81. Rubin and Hornig, "Transportation," p. 55.

82. Eric Hirst and Mayo S. Stuntz, Jr., "Urban Mass Transit

Energy Use and Conservation Potential," Energy Systems and Policy 1, no. 4 (1976), pp. 391-406.

83. Charles A. Lave, "Conservation of Energy in the Urban Passenger Sector: A General Principle and Some Proposals," Transportation Research-A 14A (1980), pp. 321-326.

84. Maltby, Monteath and Lawler, "The UK," p. 305.

85. Rowe and Glenn, "Alternative Actions," p. i.

86. Lave, "Conservation," p.322.

87. Ibid., p. 321.

88. Hirst and Stuntz, "Urban Mass Transit," p. 391.

89. Maltby, Monteath and Lawler, "The UK," p. 309.

90. French, "Transportation," p. 135.

91. F.W. Gobetz and A.A. LeShane, "Cost/Benefit Trade-Offs for Reducing the Energy Consumption of Commercial Air Transportation (RECAT)," UTRC R76-912036-17 (East Hartford, Conn.: United Technologies Research Center, June 1976), p. 27.

92. Ibid., pp. 27, 28.

93. Ibid., p. 28.

94. Boyle, "Effects," p. 31.

95. C.N.Viswanathan, R.W. Longman and G.A. Domoto, "Energy Conservation in Subway Systems by Controlled Acceleration and Deceleration," Energy Research 2 (1978), pp. 133-151.

96. Ronald W. Eash, "Energy Efficient Rail Transit Operation," Transportation Research Record 662 (1978), pp. 1-6.

97. Ibid.

98. Stuart and Hocking, "Contingency," p. 150.

99. Boyle, "Effects," p. 31.

100. Gobetz and LeShane, "Cost/Benefit," p. 27.

101. Pilati, "Energy Use," p. 440.

102. Stuart and Hocking, "Contingency," p. 151.

103. Voorhees, "Guidelines," p. 60.

104. French, "Transportation," p. 38.

105. Malliaris and Strombotne, "Demand," p. 43.

106. Carrier, "Energy Conservation," p. 495.

107. Rubin, Pollard and Hornig, "Transportation Energy," p. 53.

108. Ibid.

109. Stuart and Hocking, "Contingency," p. 150.

110. French, "Transportation," p.35.

111. Stuart and Hocking, "Contingency," p. 150.

112. Voorhees, "Guidelines," p. 60.

113. Ibid.

114. Donald A. Maxwell and Dennis V. Williamson, "How Much Fuel Does Vanpooling Really Save?" Transportation Research Record 764 (19), pp. 23-26.

115. Stuart and Hocking, "Contingency," p. 150.

116. Peter Derrick, Kathryn Stathakis and Fran Komansky, "Ride-Sharing: A Practical Transportation Alternative," (Albany, NY: New York State Legislative Commission on Critical Transportation Choices, Senator John D. Caemmerer, Chrmn., Room 811, Legislative Office Building, May 1981).

117. Scott Dever, "Vanpooling: How It's Done at Several Companies," Personnel Administrator (June 1981).

118. Peter Gordon and Peter M. Theobald, "Urban Transit Subsidies

and Vanpooling," Transportation Research 14A (1980), pp.229-234.

119. Peter J. Valk, "Evaluation of the Commuter Computer Vanpool Program," Transportation Research Record 778 (1981), pp. 32-38.

120. Steven L. Wartick, "Employer-Organized Vanpooling: A Program for the 1980s," Business Horizons 23 (1980), pp.48-56.

121. Mark D. Abkowitz and Marian T. Ott, "Review of Recent Demonstration Experiences with Paratransit Services," Transportation Research Record 778 (1981), pp. 13-19.

122. Voorhees, "Guidelines," p. 60.

123. James I. Scheiner and Stephen A. Keiper, "Car-Pool Information Project: Innovative Approaches Improve Results," Transportation Research Record 619 (1976), pp. 16-18.

124. Jarvia Shu and Lawrence Jesse Glazer, "Evaluation of the Commuter Computer Carpool Program," Transportation Research Record 778 (1981), pp. 7-12.

125. Stuart and Hocking, "Contingency," p. 147.

126. Ibid., p. 150.

127. Rowe and Glenn, "Alternative Actions," p. 6.

128. Lester A. Hoel, "Urban Transportation in North America: 4. Para-Transit," Transportation Planning and Technology 4 (1978), pp. 71-80.

129. Satish Mohan and George F. Schrader, "Pay-and-Ride Carpool: A New Concept in Commuter Ridesharing," Transportation Research Record 778 (1981), pp. 1-7.

130. K.M. Gwilliam and D.J. Banister, "Patterns of Car Usage and Restraint Modelling," Transportation 6 (1977), pp. 345-363.

131. McGillivray and Kemp, "Alternative Strategies," p. 353.

132. Terry J. Atherton, John H. Surbier, and William A. Jessiman, "Use of Disaggregate Travel Demand Models to Analyze Car Pooling Policy Incentives," Transportation Research Record 599 (1976), pp. 35-40.

133. Peter Bonsall, "Car Sharing in the United Kingdom: A Policy Appraisal," Journal of Transport Economics and Policy 15, no. 1 (January 1981), pp. 35-44.

134. Ibid.

135. Voorhees, "Guidelines," p. 60.

136. Stuart and Hocking, "Contingency," p. 147.

137. Boyle, "Effects," p. 30.

138. Hoel, "Urban Transportation," p. 75.

139. McGillivray and Kemp, "Alternative Strategies," p. 353.

140. Bert Arrillaga, "Paratransit: Strategies for Energy Conservation," Traffic Engineering 45 (November 1975), pp. 39-43.

141. Charles Carlson and Mary P. McShane, "Potential Roles for Auxiliary-Paratransit Services in an Energy Shortage," Transportation Research Board Special Report 191 (1980), pp. 48-59.

142. Daniel Roos and David Alschuler, "Paratransit - Existing Issues and Future Directions," Transportation 4 (1975), pp. 335-350.

143. Frederick J. Wegmann and Douglas Wiersig, "Comparison of an Employer-Based and a Community-Wide Rideshare Demonstration Program - Knoxville, Tennessee Experience," Transportation Research Forum 18 (October 1977), pp. 624-632.

144. Roger F. Teal, James V. Marks and Richard E. Goodhue, "Subsidized Shared-Ride Taxi Services," Transportation Research Record 778 (1981), pp. 25-32.

145. Hoel, "Urban Transportation," p. 75.

146. Voorhees and Associates, "Guidelines," p.60.

147. Stuart and Hocking, "Contingency," p. 147.

148. Ibid.

149. French, "Transportation," p. 35.

150. Carrier, "Energy Conservation," p. 495.

151. Voorhees and Associates, "Guidelines," p. 60.

152. Katie Moran, "Bicycle Transportation for Energy Conservation Technical Report" (Denver, Colorado: Mountain Bicyclists' Association, Inc., 1290 Williams Street, May 1980).

153. Ibid., p. 4.

154. Hilary Coleman, "Cycling - Why the Low Priority in Planning?" The Planner 66, no. 2 (March 1980), pp.45-46.

155. Voorhees and Associates, "Guidelines," p. 60.

156. Stuart and Hocking, "Contingency," p. 151.

157. Voorhees and Associates, "Guidelines," p. 60.

158. Hoel, "Urban Transportation," p. 78.

159. French, "Transportation," p. 36.

160. Ibid., p. 35.

161. Stuart and Hocking, "Contingency," p. 150.

162. Maltby, Monteath and Lawler, "The UK," p. 309.

163. Rubin, Pollard and Hornig, "Transportation Energy," p. 55.

164. Dickinson, "Transportation," p. 16.

165. Hirst and Stuntz, "Urban Mass Transit," p. 391.

166. McGillivray and Kemp, "Alternative Strategies," p. 359.

167. Malliaris and Strombotne, "Demand," p. 42.

168. Gene Dallaire, "Redesigning the Auto: Key to Alleviating the Nation's Energy Crisis," ASCE Civil Engineering 49 (November 1979), pp. 92-97.

169. Orski, "The Potential," p. 253.

170. Ibid.

171. Malliaris and Strombotne, "Demand," p. 42.

172. Ibid.

173. Ibid.

174. Ibid.

175. Dallaire, "Redesigning," p. 97.

176. Ibid., p. 94.

177. Maltby, Monteath and Lawler, "The UK," p. 309.

178. Dallaire, "Redesigning," p. 94.

179. Ibid., p. 95.

180. Ibid.

181. McGillivray and Kemp, "Alternative Strategies," p. 356.

182. Ibid., p. 357.

183. Frank Emerson and Howard Walton, "Projected 1985 Automobile Gasoline Savings from the House-Passed Gas Guzzler Tax and Conference Minimum Mileage Standards" Analysis Memorandum AM/EU -7802 (Washington, D.C.: Office of Energy Use Analysis, Assistant Administrator for Applied Analysis, Energy Information Administration, Department of Energy, 20461, June 1978), p. 16.

184. Ibid., p. 7.

185. N. Scott Cardell and Frederick C. Dunbar, "Measuring the Societal Impacts of Automobile Downsizing," Transportation Research-A 14A (1980), pp. 423-434.

186. Orski, "The Potential," p. 255.

187. McGillivray and Kemp, "Alternative Strategies," p. 359.

188. Ibid.

189. Jeffrey S. Milstein, "Energy Conservation and Travel Behavior," in H. Keith Hunt, Advances in Consumer Research Volume V (Ann Arbor, Michigan: Association for Consumer Research, 1978), pp. 422-425.

190. Malliaris and Strombotne, "Demand," p. p. 42.

191. Dallaire, "Redesigning," p. 94.

192. Ibid.

193. Malliaris and Strombotne, "Demand," p. 42.

194. Orski, "The Potential," p. 253.

195. Stuart and Hocking, "Contingency," p. 151.

196. Rowe and Glenn, "Alternative Actions," p. 6.

197. Emerson and Walton, "Projected 1985," p.4.

198. Maltby, Monteath and Lawler, "The UK," p. 308.

199. Edward F. Renshaw, "Recession in the US Motor Industry and the Quest for Fuel Economy," Energy Policy (March 1981), 20-24.

200. Lave, "Conservation," p. 324.

201. Malliaris and Strombotne, "Demand," p. 42.

202. Carrier, "Energy Conservation," p. 495.

203. Rowe and Glenn, "Alternative Actions," p. 6.

204. French, "Transportation," p. 35.

205. Maltby, Monteath and Lawler, "The UK," p. 305.

206. Rubin, Pollard and Hornig, "Transportation Energy," p. 51.

207. Dickinson, "Tranportation," p. 9.

208. French, "Transportation," p. 37.

209. Carrier, "Energy Conservation," p. 495

210. Maltby, Monteath and Lawler, "The UK," p. 307.

211. Orski, "The Potential," p. 252.

212. Lave, "Conservation," p. 325.

213. Milstein, "Energy Conservation," p. 424.

214. Rowe and Glenn, "Alternative Actions," p. 6.

215. Stuart and Hocking, "Contingency," p. 150.

216. Milstein, "Energy Conservation," p. 424.

217. Hugh L. Carey and James L. Larocca, "New York State Energy Conservation Plan 1977-1980" (Albany, New York: The New York State Energy Office, Agency Building 2, Empire State Plaza, October 1977), pp. 30, 31.

218. Ibid.

219. Milstein, "Energy Conservation," p. 424.

220. Roger A. Banowetz and Louis J. Bintz, "Field Evaluation of Miles-Per-Gallon Meters" Report No. DOT-TSC-OST-77-64 (Los Angeles, CA: Automobile Club of Southern California, 2601 South Figueroa Street, November 1977); M. Stephen Huntley, Jr. and William Z. Leavitt, "The Effectiveness of Miles-Per-Gallon Meters as a Means to Conserve Gasoline in Automobiles," Report No. DOT-TSC-OST-76-38 (Cambridge, MA: U.S. Department of Transportation, Transportation Systems Center, Kendall Square, October 1976).

221. Orski, "The Potential," p. 253.

222. Stuart and Hocking, "Contingency," p. 150.

223. Ibid., p. 151.

224. Ibid., p. 152.

225. Voorhees and Associates, "Guidelines," p. 60.

226. Stuart and Hocking, "Contingency," p. 151.

227. Voorhees and Associates, "Guidelines," p. 60.

228. Srinivasan et al., "Forecasting," p. 167.

229. Stuart and Hocking, "Contingency," p. 151.

230. Maltby, Monteath and Lawler, "The Uk," p. 308.

231. Stuart and Hocking, "Contingency," p. 150.

232. Ibid.

233. Gwilliam and Banister, "Patterns," p. 345.

234. Voorhees and Associates, "Guidelines," p. 60.

235. Ibid.

236. Ibid.

237. Thomas M. Corsi and Milton E. Harvey, "Energy-Crisis Travel Behavior and the Transportation Planning Process," Transportation Research Record 648 (1977), pp. 30-36.

238. McGillivray and Kemp, "Alternative Strategies," p. 352.

239. Martin E.H. Lee, "Driver- Versus Vehicle-Based Rationing and the Potential for Coupon Sales Between Different Income Groups in Michigan," TRB Special Report 191 (1980), pp. 138-144.

240. Rowe and Glenn, "Alternative Actions," p. 6.

241. Stuart and Hocking, "Contingency," p. 151.

242. Voorhees and Associates, "Guidelines," p. 60.

243. Srinivasan et al., "Forecasting," pp. 167, 169.

244. Maltby, Monteath and Lawler, "The Uk," p. 307.

245. Rowe and Glenn, "Alternative Actions," p. 6.

246. Maltby, Monteath and Lawler, "The UK," p. 307.

247. Rowe and Glenn, "Alternative Actions," p. 6.

248. David J. Barnaby and Richard C. Reizenstein, "Perspectives on the Energy Crisis: Gasoline Prices and the Southeastern Consumer," Survey of Business (September/October 1975), pp. 28-31.

249. Ibid., p. 31.

250. Orski, "The Potential," p. 249.

251. Corsi and Harvey, "Energy-Crisis," p. 30.

252. Joyce Mehring, "Potential Effect of Transport Fuel Price Increases on Enegy Consumption," Transportation Research Forum Proceedings of 1976 17, no. 1 (1976), pp. 1-6.

253. Ibid., p. 5.

254. Stuart and Hocking, "Contingency," p. 152.

255. Michael Boretsky, "Opportunities and Strategies for Energy Conservation," Technology Review 79, no. 8 (1977), pp. 56-62.

256. McGillivray and Kemp, "Alternative Strategies," pp. 351, 352.

257. Kahn, "U.S. Paper," pp. 1, 38.

258. Alan A. Tait and David R. Morgan, "Energy and the Role of Gasoline Taxation," Finance & Development (june 1978), pp. 7-11.

259. Gobetz and LeShane, "Cost/Benefit," p. 27.

260. Orski, "The Potential," p. 252.

261. French, "Transportation," p. 39.

262. Ibid.

263. Ibid., p. 40.

264. Stuart and Hocking, "Contingency," p. 150.

265. Voorhees and Associates, "Guidelines," pp. 59, 73.

266. Ibid.

267. Ibid.

268. Yosef Sheffi, "Simple Equilibrium Analysis of the Dedication of a Freeway Lane to Exclusive Bus Use," Transportation Research Record 775 (1981), pp. 7-11.

269. M.J. Rothenberg, "Priority Treatment for High Occupancy Vehicles: Project Status Report," FHWA-RD-77-56 (Alexandria, VA: JHK & Associates, Suite 1112, 4660 Kenmore Avenue, March 1977), p v.

270. Ibid., p. vi.

271. Ibid.

272. Craig Miller and Robert Deuser, "Issues in Enforcement of Busway and Bus and Carpool Lane Restrictions," Transportation Research Record 606 (1976), pp. 12-17.

273. Federal Highway Administration, "Facts from the Film," (Washington, D.C.: Urban Planning Division, 20590).

274. Maltby, Monteath and Lawler, "The UK," p. 308.

275. Eric Toder, "Highway Capacity Reduction and Fuel Consumption," Transportation Research Forum Proceedings of 1976 17, no. 1 (1976), pp. 7-15.

276. Rowe and Glenn, "Alternative Actions," p. 6.

277. Frederick A. Wagner, "Urban Transportation Energy Conservation Analysis of Traffic Engineering Actions Final Report - Volume IV," (McLean, Virginia: 6813 Market Square Drive, 22101; September 1978), p. 3.

278. Kahn, "U.S. Paper," p. 1.

279. Carey and Larocca, "New York State," pp. 30,32.

280. Rowe and Glenn, "Alternative Actions," p. 6.

281. Voorhees and Associates, "Guidelines," p. 151.

282. Marchiz Petreanu and James J. Schuster, "Energy Conservation Through Arterial Improvements," Transportation Engineering Journal 105, no. 5 (September 1979), pp. 535-548.

283. Stuart and Hocking, "Contingency," p. 151.

284. Voorhees and Associates, "Guidelines," p. 59.

285. Ibid.

286. Ibid.

287. Ibid.

288. Stuart and Hocking, "Contingency," p. 151.

289. Ibid., p. 152.

290. Voorhees and Associates, "Guidelines," p. 59.

291. Ibid., p. 60.

292. Ibid.

293. Carrier, "Energy Conservation," p. 495.

294. Malliaris and Stombotne, "Demand," p. 43.

295. Voorhees and Associates, "Guidlines," p. 60.

296. Maltby, Monteath and Lawler, "The UK," p. 308.

297. Voorhees and Associates, "Guidelines," p. 60.

298. Malliaris and Strombotne, "Demand," p. 43.

299. Carrier, "Energy Conservation," p. 495.

300. Rubin, Pollard and Hornig, "Transportation Energy," p. 52.

301. Dickinson, "Transportation," p. 25.

302. Stuart and Hocking, "Contingency," p. 150.

303. Carey and Larocca, "New York State," pp. 30,31.

304. Dickinson, "Transportation," p. 18.

305. Ibid.

306. Orski, "The Potential," p. 248.

307. Rubin, Pollard and Hornig, "Transportation Energy," p. 52.

308. French, "Transportation," p. 35.

309. Bhaltacharyya, "A Framework," p. 179.

310. Malliaris and Strombotne, "Demand," p. 43.

311. Rubin, Pollard and Hornig, "Transportation Energy," p. 56.

312. Financial Post, "Where the Rubber Meets the Railroad," 19 June 1982, p. 7.

313. Bhaltacharyya, "A Framework," p. 54.

314. Rubin, Pollard and Hornig, "Transportation Energy," p. 54.

315. French, "Transportation," p. 35.

316. Ibid.

317. See Bhaltacharyya, "A Framework," p. 179, and B. Ratcliffe and T. Fletcher, "Fuel Conservation: Much Talk but not a Lot of Action," Transport 1, no. 3 (July/August 1980), pp. 53-54.

318. Bhaltacharyya, "A Framework," p. 179.

319. Thomas M. Corsi and Merrill J. Roberts, "The Potential Fuel Efficiency Consequences of Motor Carrier Deregulation," Logistics and Transportation Review 16, no. 3, pp. 265-297.

320. Voorhees and Associates, "Guidelines," p. 60.

321. French, "Transportation," p. 39.

TARGET SEGMENTS FOR THE APPLICATION OF TRANSPORTATION ENERGY CONSERVATION ACTIONS

Targeting a Program of Social Change

From the viewpoint of the designer of a program of social change, it seems intuitively plausible that the design may have to be somehow adapted to make it appealing to different groups. For example, the Officer Friendly approach seems appropriate when encouraging elementary-school children to avoid traffic accidents, but inappropriate when admonishing impaired-driving offenders about the perils of a repeated offense.

The underlying reason for this need to adapt is the latent heterogeneity of the public. Different members of the public tend to react differently to attempts to change their behaviour. If these tendencies are strong enough, it may be worthwhile to recognize them formally by partitioning the public into segments which are internally homogeneous and externally heterogeneous. Thus, all school children may be considered similar to each other, but different from all impaired driving offenders.

The purpose of segmenting the public is to enable the program designer to target different versions of the program to the different segments. Presumably, this will increase the effectiveness of the program's impact in each segment, as compared with the alternative of using a common program design for everyone. This increase is not achieved without cost, however. The added costs of designing, producing and administering several programs tend to offset the incremental effectiveness realized from the segmented approach. Thus, the challenge is to recognize only those segments whose adoption will increase effectiveness by

more than the added costs.

The direct method for implementing a segmentation strategy is to determine the relationships between the relevant program actions and specified behaviours of the target segments. Consider the example of reducing the incidence of automobile accidents involving pedestrians. Assume that there are two possible program actions: speeches by Officer Friendly and lectures by a judge of the Traffic Court. A segmentation strategy should consider whether there are segments of the public which would respond differently to these actions. The relationships to be measured directly would be the responsiveness of each action among elementary-school children and among impaired-driving offenders. If these relationships seemed promising, the program designer might consider targeting one action at one segment, and the other action at the other segment.

Unfortunately, it is not always feasible to identify unambiguous relationships between actions and segment response. This is partly because the number of direct relationships is typically very large (equal to the product of the number of actions times the number of segments). In addition, it may be difficult to quantify some of the relationships, such as childrens' responsiveness to a speech.

One solution is to employ the indirect method. This seeks to identify proxy variables which exhibit some relationship to the actions and to the segment response. Age might be a suitable proxy variable in the above example. The resulting

segmentation strategy might be simply to let Officer Friendly make speeches to young people, and let the judge of the Traffic Court deliver lectures to adults.

The identification of suitable proxy variables is an important part of the indirect method. According to Kotler[1], their suitability can be appraised on the basis of their ability to define segments having the following features

measurable: it should be possible to acquire data which provide quantitative estimates of the relative sizes of the segments;

accessible: it should be possible to target different program actions at different segments with minimal overlap;

substantial: the segments should be important in terms of the program's objectives.

The most frequent applications of segmentation methodology have involved the analysis of markets for commercial products. Demographic and socioeconomic variables have been the most popular, possibly because they seem to satisfy the measurable and accessible criteria. Because they are usually proxy variables, it is necessary to appraise the strength of their relationships to marketing objectives. Other measures such as attitudes to the product typically exhibit stronger relationships to marketing objectives, but they may not satisfy the measurable or accessible criteria as well.

Whether a given variable is suitable for segmenting a

population is an empirical question. It is necessary to examine the relationship between the variable and the program actions, and between the variable and the responses of the target members of the population. If these relationships are strong enough, and if the use of the variable is otherwise cost-effective, then it should be suitable for segmenting the population.

The empirical nature of segmentation argues for examining those precedents in the literature where variables have exhibited relevant segmentation effects. This approach assumes that the users of the segmentation variables were satisfied with the above relationships. Subject to that assumption, it is possible to gain valuable insights about potential segmentation variables before undertaking the research.

Unfortunately, the literature of transportation energy conservation is rather sparse, and very few segmentation studies exist. The more general literature of energy conservation has become quite large, however. Also, the transportation literature which has traditionally had a dominant engineering orientation, has in recent years begun to include studies which contain segmentation implications. The strategy of this segmentation literature review will be to draw on these two sources for insights concerning potential segmentation variables for transportation energy conservation.

Our point of departure was a set of earlier reviews by Olsen and Goodnight[2], by Anderson and Cullen[3], and by Arnold

and Turner[4]. These have been augmented by a large number of more recent journal articles, book chapters, and unpublished reports. Of the many variables which were employed in these studies, eight types have been chosen for detailed examination in the remaining sections of this chapter. These are: age, education, occupation, income, sex, household characteristics, attitudes and dwelling characteristics. Each section consists of a review of the relevant findings from the energy conservation and transportation literatures, respectively. The chapter concludes with a summary section.

Age

Age and energy conservation. The consumption of gasoline was found by Ritchie et al[5] to be inversely related to age. But the relationship cannot be described adequately by the simple statement that gasoline consumption declines with increasing age. Barnaby and Reizenstein[6] classified gasoline consumers as either light, medium, or heavy. As might be expected, the medium consumers were older than the heavy consumers. However, the light consumers were the youngest of all. Apparently the relationship is non-linear, with gasoline consumption being minimal in the case of newly-formed households, increasing to a maximum with "full-nest" families, and declining thereafter.

The conservation of gasoline was shown by Hartgen and Neveu[7] to decrease with increasing age. However, Curtin[8] found that the old were less resistant to gasoline conservation than the young. Presumably, the relative lack of gasoline consumption among the old limits their opportunities for conservation.

Intentions to consume gasoline were shown by Bush and Stevens[9] to vary with age. The young tended to believe that the U.S. gasoline shortage was artificially induced or the fault of government, perhaps explaining their greater resistance to conservation efforts. The old tended to blame the oil companies. Cunningham and Peterson[10] found that the consumption intentions under increasing price scenarios were more persistent for the young than for the old. Car-purchase intentions were also shown by Greenlees[11] to vary with age. As age increases from

25 to 65 the probability of purchasing a four-cylinder car was estimated to fall from 27.7 per cent to 7.0 per cent, while the probability of purchasing an eight-cylinder car increased from 53.7 per cent to 76.3 per cent.

Studies of the consumption and conservation of other forms of energy have revealed different age effects. Ritchie et al[12] found a direct relationship between the age of the household head and the amount of in-home energy consumption, in contrast with the inverse age relationship which characterized the consumption of gasoline. Curtin[13] also found that the age effects were in the reverse direction for in-home energy conservation relative to gasoline conservation. Forty per cent of the 18 - 24 age group felt they could conserve home heating energy, versus 24 per cent of the over-65 group. Warriner's[14] study of the over-65 group revealed that the reason for the greater resistance of the elderly was that their energy consumption was already relatively low because of having smaller households with fewer appliances.

The relationships between age and attitudes to conservation have been less well defined. Good[15] found that age did not predict "energy-consciousness" among residents of six Canadian cities. Meyers[16] was able to account for barely 15 per cent of the variations in attitudes toward the conservation of gasoline by using several demographic measures including age. Hummel et al.[17] measured a significant correlation between age and one of several attitudes to the energy shortage. Notwithstanding the

measurement problems, Talarzyk and Omura[18] reported that older respondents expressed more positive attitudes towards energy conservation.

Age and transportation. Evidence of age-related differences has appeared among users of urban transportation. Middendorf and Heathington[19] compared bus riders with those who used shared-ride taxi services, and found that the bus riders tended to be senior citizens and students. Feldman[20] compared automobile users, transit users, and train commuters. Those over age 33 tended to use the train while those aged 33 or less tended to use transit.

Age effects also appear in the responses of urban travellers to differences in the attributes of travel modes. Monroe and Halvorson[21] found that disproportionate percentages of seniors and of those aged 16 or less, reported changing their trip frequencies in response to a fare decrease. Tybout et al.[22] concluded that young, middle-aged and old travellers chose to walk, drive, or take the bus on the basis of different perceptions of each mode's attributes. Neveu[23] also found that the young responded differently to the urban travel alternatives than older travellers did. Blankenship[24] identified the young low-income group as being captive to bus transit, and as having the strongest feelings about the automobile. In general, the young feel negatively about the automobile, the old feel positively about the bus and the middle-aged emphasize the need for better service.

Education

Education and energy conservation. A direct relationship between the level of education and the level of gasoline consumption was observed by Barnaby and Reizenstein.[25] Evidence of a relationship between education and gasoline conservation is less conclusive. Greenlees[26] found that those with a college education tended to exhibit relatively greater demand for four-cylinder cars and six-cylinder cars. Better-educated drivers had a greater tendency both to reduce mileage and to choose cars with fewer cylinders, according to Pitts et al.[27] And the findings of Cunningham and Peterson[28] suggest that responses to the use of high prices to encourage gasoline conservation would vary with the level of education.

However, most of the evidence of an education effect refers to the conservation of energy in general. Curtin[29] found that the highly educated tended to report that they practiced energy conservation and that they viewed further adjustments with less difficulty than those with less education. According to Talarzyk and Omura,[30] as the level of education increased more respondents reported that their activities had been altered. Reizenstein and Barnaby[31] observed a higher educational level in the conservation-oriented group of respondents. Finally, Good[32] found that energy-conscious consumers tended to be better educated than the average consumer.

The essential question is whether the general concern about energy conservation among the more-educated segment also applies

to the conservation of gasoline. In spite of the evidence cited above, Bush and Stevens[33] found that better-educated males tended to believe that the energy crisis was artificial, and that less-educated females tended to blame the oil companies.

Education and transportation. The evidence of a relationship between education and travel behaviour is rather limited. Tybout et al.[34] examined possible relationships between travel mode choice and several socio-economic measures, but found no evidence of a relationship to travellers' educational levels. Arnold and Turner[35] found that those intercity travellers who made the largest number of trips per year had the largest incidence of college degrees. Regarding other measures, Blankenship[36] observed differences in beliefs about the automobile's role in transportation which he was able to associate with the level of education.

To summarize this section, education seems to be related to energy conservation and probably to gasoline conservation. Evidence of a relationship between education and travel is rather sparse but promising. Thus, education should receive serious consideration as a segmentation variable.

Occupation

Occupation and energy conservation. The evidence concerning a relationship between occupation and energy conservation is mixed. On the affirmative side, Corsi and Harvey[37] identified groups such as clerical workers, blue-collar workers, sales representatives and professionals, which exhibited differences like switching to public transportation, car-pooling, or a smaller car. McDougall et al.[38] found that families in which both parents had occupations outside the home tended to consume more gasoline than other families. Cunningham and Peterson[39] associated occupational differences with differences in the anticipated consumption of gasoline at increased prices.

The negative evidence relates to energy conservation in general. Good[40] reported that occupation was not a significant discriminator between the "energy-conscious" group and the average group. Talarzyk and Omura[41] could find no relationship between the occupation of the husband and the effect of the energy shortage on family activities. McDougall et al.[42] found that the number of working parents could not provide sufficient incremental explanation of residential energy consumption. In constrast, Morrison and Gladhart[43] claimed that families in which both homemakers were employed full-time used eight per cent less residential energy than other families.

Occupation and transportation. Turner[44] found that three occupational groups had different perceptions of the service attributes of intercity bus, train, and automobile. Arnold and Turner[45] identified several travel-related differences which characterized

intercity travellers in various occupational groupings. Blankenship[46] studies differences in attitudes towards the automobile among professional, technical, and managerial occupations. Feldman[47] found that occupation was a significant discriminator between users of the subway, the commuter train, and the automobile. In contrast, Middendorf and Heathington[48] measured no significant differences between users of the bus and shared taxi, with respect to their employment.

Trip purpose is a related measure which has also been studied as a potential segmentation variable. Stearns[49] studied shifts in trip purposes during the 1973-74 energy crisis among those who travelled by foot, by transit or by automobile. Simmie et al.[50] measured perceptions of transit and automobile for the journey to work. Crompton and Gitelson[51] compared the anticipated travel behaviour of people travelling for business and other purposes, under varying scenarios regarding gasoline pricing and rationing.

The studies cited in this section indicate that occupation is a promising segmentation variable. Its relationship to gasoline conservation is encouraging. Trip purpose also seems to be worthy of further consideration.

Income

Income and energy conservation. Barnaby and Reizenstein[52] reported that low-income families in the U.S. tended to consume less gasoline than high-income families. This direct relationship between family income and gasoline consumption was replicated by Ritchie et al.[53] among Canadian families.

The relationship between gasoline conservation and family income is less clear, however. Hartgen and Neveu[54] found that self-reports of gasoline conservation by low-income families accounted for only 11 per cent of the total. Bush and Stevens[55] reported that higher-income males were the most likely to adopt car-pooling and to alter vacation plans. But the findings of Corsi and Harvey[56] imply that the relationship might not be monotonic, since middle-income families reported more gasoline conservation activities than either low-income familes or high-income families. This was consistent with the Reizenstein and Barnaby[57] findings that high-income drivers preferred more gasoline than middle-income drivers who were more inclined towards conservation.

Additional insights into the income relationship were provided by Cunningham and Peterson,[58] who constructed conditional demand curves relating anticipated gasoline consumption to hypothetical future price increases. These curves suggested that low-income drivers had little discretionary consumption and were relatively price-inelastic. One segment of medium-high-income drivers was similarly price-inelastic but at a much

higher level of consumption. The most price-elastic segment consisted of medium-income drivers whose consumption level was between those of low-income and high-income segments.

The size of automobile purchased is a related aspect of gasoline conservation which exhibits some income effects. Greenlees[59] found that the income elasticity of demand for eight-cylinder cars was greater than that for six-cylinder and four-cylinder cars.

The consumption and conservation of energy in general has also been related to income, although the findings have been ambiguous. On the positive side, Ritchie et al.[60] found that in-home energy consumption was directly related to the level of family income. Morrison and Gladhart[61] reported on the basis of a five-year longitudinal study, that family income was the single best indirect predictor of residential energy consumption.

In contrast, the relationship between energy conservation and income is not clear. Curtin[62] studied five income categories but found that neither high nor low income groups were consistently associated with past conservation efforts. Bennett and Moore[63] elicited preferences for five alternative energy-conservation programs but could find no significant associations between income and the resulting preferences. Talarzyk and Omura[64] found only a weak relationship between household income and energy-conserving activities. Good[65] concluded that income was not a significant discriminator between "energy-conscious" consumers and others.

Thus, segments defined by income level may be useful for identifying patterns of the consumption of both gasoline and household energy. But such segments may have limited usefulness for locating conservation segments.

Another problem with the use of income segmentation should be noted in passing. Herendeen[66] distinguished between the proportion of household energy consumption which is purchased directly and that which is obtained indirectly through other products and services. The direct proportion was found to vary inversely with income, dropping to only one-third in high-income households. Most of the energy consumed by such households would not be accessible to conventional conservation appeals. At the other end of the income scale are the low-income elderly, whose energy usage Warriner[67] studied. Although they seem to spend proportionately a lot on energy, their low absolute energy usage makes them poor prospects for energy conservation programs.

Income and transportation. The relationship between income and travel behaviour is complicated by the existence of various purposes for travelling. Oster[68] found a direct relationship between the level of income and the amount of discretionary travel. Witkowski and Taylor[69] argued that higher-income groups can reduce their discretionary travel rather than switching modes. Stearns'[70] results illustrated this phenomenon. She found that more switching from the car to other modes occurred below the poverty level of income than above it.

The strength of the income relationship varies depending

on the travel mode being considered. Dobson and Tischer[71] measured an inverse relationship between income level and bus usage, but no relationship between income level and either car-pooling or single-occupancy car usage. Arnold and Turner[72] described the high-income traveller as taking more frequent trips and tending to use the car or the train but not the bus. Solomon and George[73] found that more medium-income drivers were using the highway during the 1974 energy crisis, and relatively fewer after the crisis.

Income level can also be associated with certain non-behavioural measures. The Canadian Weekend[74] poll related preferences for train, bus, and airplane to income level. Blankenship found income-related difference in attitudes to the car and the bus. Dumas and Dobson[75] found no significant correlations between income and travel behaviour, but claimed that there were important indirect effects on other travel determinants.

This section has identified a number of applications in the fields of energy consumption and transportation where income offers some promise as a segmentation variable. Several questions remain however, particulary with respect to the relevance of income to conservation. Thus, income seems to be a variable which should be used with considerable caution.

Sex

Sex and energy conservation. The relationship between sex and energy conservation is tenuous at best. Hartgen and Neveu[76] found that the amounts of conservation in travel reported by men and women were approximately equal, but that men reported savings in work travel whereas women reported savings in shopping travel. Both sexes estimated the same amounts of savings from future vacation travel, and no significant differences were found in the male-female proportions among highway tourists by Solomon and George.[77]

Regarding preferences, Greenlees[78] reported that women tended more than men to prefer six-cylinder cars to fours or eights. Bennet and Moore[79] found little difference between men and women in their preferences among five alternative energy programs.

Kushler and Jeppesen[80] measured more positive attitudes towards energy conservation among female students. And Neveu[81] reported that women tended to be more apprehensive than men regarding an energy shortage and the need to encourage the use of transit. Bush and Stevens[82] found that those who felt the gasoline shortage was artificial tended to be male, while those who blamed it on the oil companies tended to be female. However, no significant differences between the energy-conservation attitudes of men and women were found in studies by Curtin,[83] by Good,[84] or by Meyers.[85]

Sex and transportation. Blankenship reported that female travellers within the city were more receptive to public

transportation and less likely to depend on the automobile than men were. Commuters who travel to work in multiple-occupant automobiles are more likely to be female, according to Dobson and Tischer.[86] In their study of bus and shared-taxi users, Middendorf and Heathington[87] found that women were the principal users. Among intercity travellers however, Arnold and Turner[88] found that housewives used the car more than average, the bus less than average, and the train the same as the average of all travellers.

Household Characteristics

There are three types of household characteristics which can be considered as potential segmentation variables: household size, family life-cycle, and social class. Each of these will be discussed in the following sections.

Household size and energy conservation Differences in family size were directly associated with gasoline consumption according to Barnaby and Reizenstein[89]. Low-usage families tended to be younger with fewer children, while heavy-usage families tended to be large with children in the 6-14 age range. Regarding the consumption of residential energy, a similar direct relationship to household size has been found in studies by Morrison and Gladhart[90], by Ritchie et al[91], and by Warriner[92]. Klausner[93] provided an interesting rationale for this relationship by relating energy consumption to social complexity, size of kinship network, and social intensity of household activity.

The conservation of energy used in shopping trips was found by Corsi and Harvey[94] to be greater in families with one or two children than in childless households. Curtin concluded that the relationship between family size and energy conservation was curvilinear, with the greatest degree of conservation occurring in families of three or four people. Pitts et al[95] associated family size with the reduction of mileage driven and with the change to a smaller car. In related research, Greenlees[96] observed that childless couples tended towards cars with larger

engines.

Research on the relationship between family size and attitudes or preferences regarding conservation, has produced mixed results. Meyers[97] found that family size was one of the best predictors of attitudes to different methods for conserving gasoline. However, Kushler and Jeppeson[98] could not find a relationship between family size and attitudes to energy conservation. Bennett and Moore[99] also found that family size was not related to preferences among alternative energy conservation programs.

Household size and transportation Two studies have investigated the relationship between household characteristics and the travel mode used for urban trips. Dobson and Tischer[100] found that bus-users could be distinguished from car-poolers on the basis of the numbers of people in their respective households who work and hold a driver's license. Oster[101] measured the relationship between the number of family members in different age categories and the number of non-work destinations per week.

Perceptions of travel modes were also shown to be related to household characteristics. Dumas and Dobson[102] found that characteristics such as household size, number of workers, and number of drivers were related to peoples' perceptions of the amount of comfort provided by the bus.

Thus, there is considerable evidence that various measures of household size are related to transportation energy consumption and conservation. The use of household size as a segmentation variable would seem to merit further study.

Family life-cycle Barnaby and Reizenstein[103] related differences in gasoline consumption to the stages of the family life-cycle. The low-consumption segment tended to consist of young singles or couples in the early family stage, whereas the heavy-consumption segment tended to be full-nest families having children in the 6-14 age-range. Similar findings for residential energy consumption were obtained by Morrison and Gladhart[104]. They reported that families in the child-rearing stages consumed more energy than families without children. However, the relationship was curvilinear, with energy consumption decreasing after the child-rearing stage.

Energy conservation was also found to be related to the stage of the family life-cycle. Pitts et al[105] found that those who decreased the mileage driven tended to be at the empty-nest stage, whereas those who increased mileage tended to be at the full-nest stage. Similarly, those who down-sized to a smaller car tended to be at the empty-nest stage.

Travel behaviour was related to the family life-cycle by Zimmerman[106]. Not only did she find that aggregate family mobility varied over the life-cycle, but also that there were different patterns of variations for different purposes such as the work trip and the recreational trip.

Social class and ethnicity Using the Census index of social class (based on income, education and occupation), Cunningham and Peterson[107] found a relationship with anticipated changes in gasoline consumption in response to hypothetical price increases.

They concluded that low-index drivers had less discretion in responding to high prices than high-index drivers.

There is some evidence that ethnic background influences energy-conservation practices. Pitts et al[108] found that race was the most important factor which differentiated between those who practiced conservation. White drivers tended to reduce mileage and change to smaller cars, while non-white drivers tended to do neither. Greenlees[109] also found that eight-cylinder cars tended to be preferred by non-whites. Comparing the travel modes used by whites and blacks, Dobson and Tischer[110] found that whites were under-represented among bus-riders and blacks were under-represented among car-poolers. However, Curtin[111] reported that race was one of several demographic measures which explained only a small amount of the variations in energy conservation during the 1973-74 crisis.

While there appear to be some associations between transportation energy usage and social class or ethnicity, these may be primarily the effects of the socio-economic associations which have already been noted. In particular, education and occupation may overlap the effects noted above and may be preferable for use as segmentation variables.

Attitudes

Attitudes and energy conservation A number of studies have measured attitudes, preferences and beliefs about various aspects of energy conservation, and then associated these measures with various characteristics of the people who possess them. Several such studies will be described below. However, it is first necessary to acknowledge that the relationship between actual conservation behaviour and measures of attitude, preference or belief has not been well established. Thus, Morrison and Gladhart[112] stated"....belief in the reality of U.S. energy problems did not diminish in any meaningful way the energy consumed in the household." Verhallen and Raaij[113] monitored the energy-consuming behaviour of 145 households and concluded that the relationship between behaviour and eight attitude measures was not significant.

Belief in the energy crisis seems to be related to attitudes and preferences concerning it. Meyers[114] found that those who did not believe that an energy problem exists were the least agreeable to conserving gasoline. Bennett and Moore[115] compared believers with non-believers in the energy crisis, and found that more than twice as many of the latter preferred the status quo rather than more stringent conservation programs. If energy-consciousness is a determinant of energy attitudes and preferences, it may be useful to know what kinds of people tend to be energy-conscious. Good[116] described them as being more cosmopolitan, better educated and possessing a stronger drive for information

than the average.

While actual energy-conserving behaviour has not been strongly associated with attitudes, self-reported behaviour has exhibited stronger associations. Barnaby and Reizenstein[117] claimed that those who reported low gasoline usage had the strongest attitude in favour of rationing, and the converse. Pitts et al found that those who reported that they had reduced their mileage and switched to a smaller car had different attitudes from those who reported neither of these behaviours.

Attitudes and transportation Many studies have measured the attitudes and other attributes of users of different travel modes, and attempted to apply the resulting profiles to predict mode use. Thus, Dobson and Tischer[118] concluded that urban travellers' perceptions of travel by bus, car-pool, and single-occupant automobile were significantly correlated with the probability of mode choice. Furthermore, Dumas and Dobson[119] claimed that mode choice was predicted best when the measures used had a strong affective or evaluative component. However, Arnold and Turner[120] compared the minority of a sample of intercity travellers who made the majority of trips, and found that their scores on 11 attitude items were similar to those of the total sample. Gilbert and Foerster[121] discussed conflicting evidence regarding the predictive power of attitudes, and predicted that some types of attitudes are useful but some are not. Prediction is also more reliable when the competing modes have distinctive profiles, as was illustrated by Feldman[122].

It seems that the use of attitudes in research on energy conservation and transportation is evolving. While attitudes have considerable potential as future segmentation variables, their use requires caution until the conditions governing their predictive reliability are known.

Dwelling Characteristics

Three types of dwelling characteristics might provide measures for segmenting the population with regard to energy conservation. These are physical characteristics, home location, and possession of automobiles and appliances.

Physical characteristics Studies by Richie et al [123] and by Morrison and Gladhart [124] confirmed the expected direct relationship between residential energy consumption and size of home, number of floors, rooms, windows and doors. Multiple-family dwellings used less energy than single-family dwellings. Higher thermostat setting and presence of a fireplace were associated with more energy use, while use of electric heating and water heating were associated with less energy use. Verhallen and Raaij[125] found that 24 per cent of the variation in the energy consumption of attached houses could be explained by use of insulation, whether fully-attached or semi-attached, neighbour's energy use and wind orientation.

No relationship between dwelling characteristics and energy conservation has been established. Kushler and Jeppesen[126] found that size as measured by the number of rooms exhibited no relationship to reported conservation behaviour and only a weak

relationship to conservation attitudes. Bennett and Moore[127] could find no relationship between preferences for energy-conservation programs and whether the home was owned or rented.

However, Dumas and Dobson[128] reported that people living in apartments tended to evaluate car-pooling more highly than other people. And Dobson and Tischer[129] found that people living in single-family detached homes tended to use the bus less but the car-pool more.

Home location In general, differences in energy consumption might be expected because of regional differences or because of rural-urban differences. Ritchie et al[130] found evidence of the former type in the relatively low consumption of residential energy in Quebec and the Atlantic provinces. However, they attributed this finding to differences in dwelling size relative to the other provinces. Hartgen and Neveu[131] reported that regional differences in gasoline conservation occurred between upstate and downstate New York. Geographic differences were also reported by Corsi and Harvey[132] with respect to the increased use of car-pooling and other distance-related adjustments in the work trip. Curtin[133] found that regional differences in the conservation of home heating, electricity and gasoline could not be completely explained by climatic variations. However, Talarzyk and Omura[134] found only minor regional differences in attitudes and reported energy-conserving behaviour.

The rural-urban differences were ambiguous. Ritchie et al[135] failed to find a difference in gasoline consumption. Nor did

Bennett and Moore[136] find significant differences in preferences among alternative energy-conservation programs. Greenlees[137] reported no rural-urban differences in the purchases of cars having four, six or eight cylinders. In contrast, Meyers[138] claimed that one of the best predictors of attitudes towards gasoline conservation measures was rural-urban location. Morrison and Gladhart[139] reported that "....urban and rural families differed sharply in their acceptance of 20 specific policies...." to relieve the energy crisis. Neveu[140] found that rural residents were more in favour of reducing gasoline use, whereas city residents favoured encouraging transit use. However, Curtin[141] claimed that urban residents had a greater tendency than rural residents to report that they could reduce gasoline consumption.

Finally, it is necessary to acknowledge the constraining effect of home location on the availability of public transportation. Middendorf and Heathington[142] found that bus users tended to live within one block of the bus route, while taxi users were more likely to live four or more blocks away.

Possession of automobiles and appliances: McDougall et al[143] measured a direct relationship between gasoline consumption and the number and mean weight of vehicles owned. But gasoline conservation was found by Curtin[144] to be inversely related to the number of cars owned. This inverse relationship was substantiated by the Dobson and Tischer[145] finding that users of the bus and the taxi tended to have no more than one car. Middendorf and

Heathington[146] found similar evidence. However the nature of the relationship is confused by the claim by Hartgen and Neveu[147] that families having more than two cars were responsible for half of the gasoline conserved in the state of New York in 1979. The types of car may be a mediating factor. Greenlees[148] found that two-car families were more likely than one-car families to purchase four-cylinder or six-cylinder cars. Also Kushler and Jeppesen[149] claimed that students who owned subcompact cars had the most positive attitudes towards energy conservation, followed by owners of compact, mid-size and full-size cars.

Ambiguity also surrounds the nature of the effect of appliance ownership on in-home energy consumption. Morrison and Gladhart[150] claimed that the number of major appliances in the home was "....an important determinant of household energy use." Warriner[151] implied a similar relationship when he argued that one reason why elderly people consume less energy in their homes is because they own fewer appliances. However, McDougall et al[152] measured no significant association between appliance ownership and aggregate in-home energy consumption.

In retrospect, this section contains some interesting findings in individual studies concerning potential segmentation variables. However, caution must be exercised when interpreting them for two reasons. First, the findings of some individual studies contradict the findings of others, thereby creating ambiguity about the usefulness of the variables. Second, many of the findings refer to in-home energy, so it is necessary to establish that they are also relevant for transportation energy.

Transportation Energy Conservation Segments

At the beginning of this chapter it was suggested that a "good" segmentation variable should define segments which are measurable, substantial, and accessible. Evidence of measurability would be provided by the prior use of the variable in one or more empirical studies. Whether the segments would be substantial from the standpoint of transportation energy conservation depends on the relevance of the study. Clearly, some question remains whether a variable which characterizes conservers of residential energy would also characterize conservers of transportation energy. But the most difficult of the three criteria to assess is whether the variable defines segments which would be accessible from the standpoint of the various actions which the program might employ. For this reason, the final choice of the segmentation variable(s) must await the definition of subsequent work to be proposed. These considerations are intended not to discourage use of the variables, but as a general caveat that they be selected with care in spite of any apparent success in prior studies.

The output of this chapter should be not only a review of what is known about potential segmentation variables, but also a recommendation concerning the most promising subset of them which should receive further consideration. The various sources which have been reviewed in the preceding sections provided empirical evidence of some of the merits of the eight variables.

Subject to the above caveat, that evidence can now be used to produce a rank-ordering of the eight variables from the most promising to the least promising. How many of the upper-ranking variables are used will depend on the nature and scope of the subsequent work to be proposed.

Table 1 provides a summary judgment of the relationship between each of the eight segmentation variables and the five activities of interest. The strength of each relationship is arbitrarily judged to be strong(S), medium (M) or weak (W), on the basis of the review of the related studies in the literature. The few cells for which no studies were found are left blank.

It is clear from Table 1 that age and household characteristics should be at the top of the ranking of segmentation variables. Equally obvious, sex and attitudes should be at the bottom. Of the remaining four variables, dwelling characteristics is probably the least useful since its strengths are primarily with respect to residential energy conservation. Education would seem to dominate occupation and income, because of its relative strength in the relationship with energy conservation.

The tentative rank-ordering (from most to least promising) based on Table 1 and a detailed examination of the findings, is as follows:

age
household
education
occupation
income
dwelling
attitudes
sex

TABLE 1: STRENGTHS (S) AND WEAKNESSES (W) OF SEGMENTATION VARIABLES

	GASOLINE CONSUMPTION	GASOLINE CONSERVATION	ENERGY CONSUMPTION	ENERGY CONSERVATION	TRANSPORTATION
AGE	S	S	S	S	S
EDUCATION	S	M		S	M
OCCUPATION	S	M	M	W	S
INCOME	S	M	M	W	M
SEX		W		W	S
HOUSEHOLD	S	S	S	S	S
ATTITUDES		M		M	M
DWELLING	M	M	S	M	W

FOOTNOTES

1. Philip Kotler, Marketing Management: Analysis, Planning and Control (Englewood Cliffs; N.J.: Prentice-Hall Inc. 1976), third edition, p. 143.

2. Marvin E. Olsen and Jill A. Goodnight, Social Aspects of Energy Conservation (Washington: U.S. Department of Commerce, 1977), National Technical Information Service, PB266029, Report No. NEPP I-B.

3. Dennis C. Anderson and Carman W. Cullen "Energy Research on Consumers: A Literature Review", Proceedings of the Administrative Sciences Association of Canada 1978 Conference, University of Western Ontario, London, Ontario.

4. Stephen J. Arnold and Ronald E. Turner, Change Strategies for Transportation Energy Conservation (Toronto: Ministry of Transportation and Communications 1978).

5. J.R. Brent Ritchie, Gordon H.G. McDougall and John D. Claxton, "Complexities of Household Energy Consumption and Conservation", Journal of Consumer Research, 8, (December 1981), pp. 233-241.

6. David J. Barnaby and Richard C. Reizenstein, Attitudes Toward Energy Consumption: Segmenting the Gasoline Market, "Proceedings of the Sixth Annual Conference, Association for Consumer Research, (1976), pp. 246-251.

7. David T. Hartgen and Alfred J. Neveu, The 1979 Energy Crisis: Who Conserved How Much? (Albany, New York: State Department of Transportation, 1980).

8. Richard T. Curtin "Consumer Adaptation to Energy Shortages", Journal of Energy and Development, 2, 1 (Autumn, 1976), pp. 38-59.

9. James R. Bush and Robert E. Stevens, "Tulsa Talks About the Gas Crisis", Business Horizons, 23, 2, (1980), pp. 31-35.

10. William H. Cunningham and Robert A. Peterson, "Market Segmentation by Gasoline Consumption Intentions," Contemporary Marketing Thought. Proceedings of the 1977 Educators Conference, American Marketing Association, (1977), pp. 105-109.

11. John S. Greenlees "Gasoline Prices and Purchases of New Automobiles", Southern Economic Journal, 47, 1, (1980), pp. 167-178.

12. Ritchie et al, "Complexities".

13. Curtin, "Consumer Adaptation."

14. G. Keith Warriner "Electricity Consumption by the Elderly," in Consumers and Energy Conservation (International Perspectives on Research and Policy Options), ed. John D. Claxton, C. Dennis Anderson, J.R. Brent Ritchie and Gordon H.G. McDougall, (New York: Praeger Publishers, 1981), pp. 69-80.

15. Walter S. Good, "Canadian Attitudes toward Energy Conservation: Implications for Public Policymakers," in Public Policy Issues in Marketing, eds. Ferrell, O.C. and Raymond laGarce (Lexington, Mass: Lexington Books, 1975) pp. 146-159.

16. C.E. Meyers, "Factors Affecting Willingness to Conserve Gasoline (Abridgment)," Transportation Research Record, 751, (1980), pp. 27-30.

17. Carl F. Hummel, Lynn Levitt and Ross J. Loomis, "Perceptions of the Energy Crisis: Who Is Blamed and How Do Citizens React to Environmental - Lifestyle Trade-Offs?", Environment and Behavior, 10, (March 1978), pp. 37-88.

18. W. Wayne Talarzyk and Glenn S. Omura, "Consumer Attitudes Toward and Perceptions of the Energy Crisis," Combined Proceedings. Spring and Fall Conferences, American Marketing Association, 1974, pp. 316-322.

19. David P. Middendorf and Kenneth W. Heathington, "Bus and Shared-Ride Taxi Use in Two Small Urban Areas," Transportation Research Record, 606 (1976), pp. 48-53.

20. Lawrence P. Feldman, "The Marketing of Urban Mass Transit," Combined Proceedings - Spring and Fall Conferences, American Marketing Association, 1973, 415-420.

21. Charles B. Monroe and Peter C. Halvorson, "The Impact of Changes in Pricing Upon Transit Riders of Varying Ages in Chicago," Professional Geographer, 32, 8, (1980), pp. 335-342.

22. Alice M. Tybout, John R. Hauser, and Frank S. Koppleman, "Consumer Oriented Transportation Planning: An Integrated Methodology for Modeling Consumer Perceptions, Preference and Behaviour," Advances in Consumer Research - Proceedings, Eighth Annual Conference, Association for Consumer Research, 1977, pp. 426-434.

23. Alfred J. Neveu, Public Opinion Survey on Energy and Transportation. (New York: State Department 8 Transportation, 1977).

24. Douglas P. Blankenship, "Segmentation Analysis of Transit Users and Nonusers", Transportation Research Record, 590, (1976), pp. 1-4.

25. Richard C. Reizenstein, and David J. Barnaby, "An Analysis of Selected Consumer Energy-Environment Trade-Off Segments," Marketing: 1776-1976 and Beyond, Proceedings of the 1976 Fall Educators Conference, American Marketing Association, 1976, pp. 522-526.

26. Greenlees, "Gasoline Prices."

27. Robert E. Pitts, John F. Willenborg and Daniel L. Sherrell, "Consumer Adaptation to Gasoline Price Increases", Journal of Consumer Research, 8, (December 1981), pp. 322-329.

28. Cunningham and Peterson, "Market Segmentation".

29. Curtin, "Consumer Adaptation".

30. Talarzyk and Omura, "Consumer Attitudes".

31. Reizenstein and Barnaby, "Trade-Off Segments".

32. Good, "Canadian Attitudes".

33. Bush and Stevens, "Tulsa Talks".

34. Tybout et al, "Preference and Behavior".

35. Stephen J. Arnold and Ronald E. Turner, Segmenting the Travel Market for Rail Passenger Communications, (Kingston, Ontario: Canadian Institute of Guided Ground Transport), Queen's University, March 1979.

36. Blankenship, "Segmentation Analysis".

37. Thomas M. Corsi and Milton E. Harvey, "Energy-Crisis Travel Behavior and the Transportation Planning Process", Transportation Research Record, 648, (1977), pp. 30-36.

38. Gordon H.G. McDougall, J.R. Brent Ritchie and John P. Claxton, "Analysis of Consumer Energy Consumption", in Consumers and Energy Conservation (International Perspectives on Research and Policy Options) eds. John D. Claxton, C. Dennis Anderson, J.R. Brent Ritchie and Gordon H.G. McDougall, (New York: Praegar Publishers, 1981), pp. 11-22.

39. Cunningham and Petersen, "Market Segmentation".

40. Good, "Canadian Attitudes".

41. Talarzyk and Omura, "Consumer Attitudes".

42. McDougall et al, "Consumer Energy Consumption".

43. Bonnie Maas Morrison and Peter Gladhart, "Energy and Families: The Crisis and Response", Journal of Home Economics, (January, 1976). pp. 15-18.

44. Ronald E. Turner, Perceptions of Passenger Service: A Case Study of a Change in Train Frequency (Kingston, Ontario: Canadian Institute of Guided Ground Transport),Queen's University, January 1977.

45. Arnold and Turner, "Rail Passenger Communications", (1979).

46. Blankenship, "Segmentation Analysis"

47. Feldman, "Urban Mass Transit".

48. Middendorf and Heathington, "Bus and Shared-Ride Taxi".

49. Mary D. Stearns, "Behavioural Impacts of the Energy Shortage: Shifts in Trip-Making Characteristics," Transportation Research Record, 592 (1976), pp. 38-40.

50. Patricia Simmie, Ian Fenwick and Roger Heeler, "Perceptions of Transit Modes: A Preliminary Analysis". Proceedings of the Administrative Sciences Association of Canada 1982 Conference, University of Ottawa, Ottawa, Ontario.

51. John L. Crompton and Richard J. Gitelsen, "Consumer Reactions to the Standby Motor Fuel Rationing Plan," Journal of Travel Research, 14, 4, (1981), pp. 27-36.

52. Barnaby and Reizenstein, "Attitudes".

53. Ritchie et al, "Complexities".

54. Hartgen and Neveu, "The 1979 Energy Crisis".

55. Bush and Stevens, "Tulsa Talks".

56. Corsi and Harvey, "Energy-Crisis Travel Behavior".

57. Reizenstein and Barnaby, "Trade-Off Segments".

58. Cunningham and Peterson, "Market Segmentation".

59. Greenlees, "Gasoline Prices".

60. Ritchie et al, "Complexities".

61. Morrison and Gladhart, "The Crisis and Response".

62. Curtin, "Consumer Adaptation".

63. Peter D. Bennett and Noreen Klein Moore, "Consumers' Preferences for Alternative Energy Conservation Policies: A Trade-Off Analysis", Journal of Consumer Research, 8, (December 1981), pp. 313-321.

64. Talarzyk and Omura, "Consumer Attitudes".

65. Good, "Canadian Attitudes".

66. Robert A. Herendeen, "Affluence and Energy Demand", Mechanical Engineering, 9, 6, October 1974, pp. 18-22.

67. Warriner, "Electricity".

68. C.V. Oster, Jr., "Second Role of the Work Trip-Visiting Nonwork Destinations (Abridgement)", Transportation Research Record, 728, (1979), pp. 79-82.

69. James M. Witkowski and William C. Taylor, "Urban Transportation Planning Under Energy Constraints", Transportation Research Record, 707, (1979), pp. 1-5.

70. Stearns, "Behavioral Impacts".

71. Ricardo Dobson and Mary Lynn Tischer, "Beliefs About Buses, Carpools and Single Occupant Autos: A Market Segmentation Approach", Transportation Research Forum Proceedings of 1976, 17, 1, pp. 200-209.

72. Arnold and Turner, "Rail Passenger Communications". (1979).

73. Paul J. Solomon and William R. George, "An Empirical Investigation of the Effect of the Energy Crisis on Tourism", Journal of Travel Research, 14, 3, (1976), pp. 9-13.

74. Canadian Weekend Poll, Canadian Weekend Magazine, (1979).

75. Joseph S. Dumas and Ricardo Dobson, "Linking Consumer Attitudes to Bus and Carpool Usage", Transportation Research, 13A, pp. 417-423.

76. Hartgen and Neveu, "The 1979 Energy Crisis".

77. Solomon and George, "Empirical Investigation".

78. Greenlees, "Gasoline Prices".

79. Bennett and Moore, "Consumers' Preferences".

80. Martin G. Kushler and John C. Jeppesen "Teenage Consumers and Energy Conservation", in Consumers and Energy Conservation (International Perspectives on Research and Policy Options), eds. John D. Claxton, C. Dennis Anderson, J.R. Brent Ritchie and Gordon H.G. McDougall, (New York: Praeger Publishers, 1981), pp. 56-68.

81. Neveu, "Public Opinion".

82. Bush and Stevens, "Tulsa Talks".

83. Curtin, "Consumer Adaptation".

84. Good, "Canadian Attitudes".

85. Meyers, "Factors".

86. Dobson and Tischer, "Beliefs About Buses".

87. Middendorf and Heathington, "Bus and Shared-Ride Taxi".

88. Arnold and Turner, "Rail Passenger Communications", (1979)

89. Barnaby and Reizenstein, "Attitudes".

90. Morrison and Gladhart, "The Crisis and Response".

91. Ritchie, et al, "Complexities".

92. Warriner, "Electricity".

93. Samuel Z. Klausner, "Social Order and Energy Consumption in Matrifocal Households", Human Ecology, 7, 1, (1979), pp. 21-39.

94. Corsi and Harvey, "Energy-Crisis Travel Behavior".

95. Pitts, et al, "Gasoline Price Increases".

96. Greenlees, "Gasoline Prices".

97. Meyers, "Factors".

98. Kushler and Jeppesen, "Teenage Consumers".

99. Bennett and Moore, "Consumers' Preferences".

100. Dobson and Tischer, "Beliefs About Buses".

101. Oster, "Second Role".

102. Dumas and Dobson, "Linking Consumer Attitudes".

103. Barnaby and Reizenstein, "Attitudes".

104. Morrison and Gladhart, "The Crisis and Response".

105. Pitts, et al, "Gasoline Price Increases".

106. Carol A. Zimmerman, "Household Travel Patterns by Life Cycle Stage", in Consumers and Energy Conservation (International Perspectives on Research and Policy Options), eds. John D. Claxton, C. Dennis Anderson, J.R. Brent Ritchie and Gordon H.G. McDougall, (New York: Praeger Publishers, 1981), pp. 81-95.

107. Cunningham and Peterson, "Market Segmentation".

108. Pitts, et al, "Gasoline Price Increases".

109. Greenlees, "Gasoline Prices" .

110. Dobson and Tischer, "Beliefs About Buses".

111. Curtin, "Consumer Adaptation".

112. Morrison and Gladhart, "The Crisis and Response".

113. Theo M.M. Verhallen and W. Fred van Raaij, "Household Behavior and Energy Use" in Consumers and Energy Conservation (International Perspectives on Research and Policy Options), eds. John D. Claxton, C. Dennis Anderson, J.R. Brent Ritchie and Gordon H.G. McDougall, (New York" Praeger Publishers, 1981), pp. 32-46.

114. Meyers, "Factors".

115. Bennett and Moore, "Consumers' Preferences".

116. Good, "Canadian Attitudes".

117. Barnaby and Reizenstein, "Attitudes".

118. Dobson and Tischer, "Beliefs About Buses".

119. Dumas and Dobson, "Linking Consumer Attitudes".

120. Arnold and Turner, "Rail Passenger Communications", (1979)

121. Gorman Gilbert and Foerster, "The Importance of Attitudes in the Decision to Use Mass Transit", Transportation, 6, (1977), pp. 321-332.

122. Feldman, "Urban Mass Transit".

123. Ritchie, et al, "Complexities".

124. Morrison and Gladhart, "The Crisis and Response".

125. Verhallen and Raaij, "Household Behavior".

126. Kushler and Jeppesen, "Teenage Consumers".
127. Bennett and Moore, "Consumers' Preferences".
128. Dumas and Dobson, "Lining Consumer Attitudes".
129. Dobson and Tischer, "Beliefs About Buses".
130. Ritchie et al "Complexities".
131. Hartgen and Neveu, "The 1979 Energy Crisis".
132. Corsi and Harvey, "Energy-Crisis Travel Behavior".
133. Curtin, "Consumer Adaptation".
134. Talarzyk and Omura, "Consumer Attitudes".
135. Ritchie, et al, "Complexities".
136. Bennett and Moore, "Consumers' Preferences".
137. Greenlees, "Gasoline Prices".
138. Meyers, "Factors".
139. Morrison and Gladhart, "The Crisis and Response".
140. Neveu, "Public Opinion".
141. Curtin, "Consumer Adaptation".
142. Middendorf and Heathington, "Bus and Shared-Ride Taxi".
143. McDougall, et al, "Consumer Energy Consumption".
144. Curtin, "Consumer Adaptation".
145. Dobson and Tischer, "Beliefs About Buses".
146. Middendorf and Heathington, "Bus and Shared-Ride Taxi".
147. Hartgen and Neveu, "The 1979 Gas Crisis".
148. Greenlees, "Gasoline Prices".
149. Kushler and Jeppesen, "Teenage Consumers".
150. Morrison and Gladhart, "The Crisis and Response".
151. Warriner, "Electricity".
152. McDougall, et al, "Consumer Energy Consumption".

A Typology of Change Processes

A large number of actions that might be taken to conserve transportation energy were identified in the preceding chapter. For example, maximum highway speeds might be reduced to a more fuel-efficient level, or more commuters might be transported by public transit. Aside from the question of which of the many actions should be implemented, is the equally challenging question of how the chosen actions should be implemented. Should legislation be introduced to lower the legal maximum highway speed limit? Should an advertising campaign be launched to inform commuters about the merits of travelling by transit? Unfortunately, even penalty-backed laws are sometimes broken, and advertising which is informative to some commuters is overlooked by others.

To choose appropriate methods for implementing conservation actions it is necessary to understand the processes by which social change occurs. The objectives of this chapter are to identify and explain the principal types of change processes, and also to review the relevant literatures for examples of their implementation.

A review of the literature of social change[1] suggests that there are four basic types of change processes. These are labelled compliance, identification, internalization, and consistency. The four change processes can be differentiated from each other on the basis of two criteria:

1. whether the motivation for the change is perceived by

the individual as coming from an extrinsic source or whether it is intrinsic to the individual

2. whether the initial impact is to change the individual's behaviour or attitudes.

Figure 1 illustrates the differences between the four change processes. The compliance process is seen as having extrinsic motivation and resulting in a behavioural change initially. A commonplace example would be the driver who obeys the speed limit to avoid being fined. The identification process is also seen as having extrinsic motivation but the initial result is an attitude change. The television viewer who develops a more positive attitude toward energy conservation because of an endorsement by a celebrity whom he admires, would be an example of the working of this process. The internalization process appeals to motivation which is intrinsic to the individual, and results in an initial change in beliefs. An example would be the patriot who is in favour of gasoline conservation after learning how dependent on foreign sources the country has become. The consistency process also appeals to intrinsic motivation but this results in an initial behavioural change. The person who agrees to speak on behalf of energy conservation and afterwards feels a commitment to the cause, would be an example of this process.

Before proceeding, it should be acknowledged that the typology recognizes that behavioural change may precede or follow non-behavioural change. This is consistent with the findings of

Figure 1: Typology of Social Change Processes

PERCEIVED SOURCE OF MOTIVATION	IMPACT OF INITIAL CHANGE	
	BEHAVIOURAL	NON-BEHAVIOURAL
EXTRINSIC	compliance process	identification process
INTRINSIC	consistency process	internalization process

recent research in the fields of communications and consumer information processing[2].

Each of the four types of social change processes is discussed in the four sections of this chapter which follow. Examples from the literatures of energy conservation and transportation are employed wherever they are available, but other examples are used as well. The chapter concludes with some summary comments about the relative merits of employing each of the four processes.

The Compliance Process

This process assumes that change will not take place unless the target of the change is confronted with a reward or penalty which he cannot resist. In these circumstances, the change is adopted, not because of its intrinsic appeal, but because adopting it is the means for obtaining the reward or avoiding the penalty. Thus, there are two variations of the compliance process, depending on whether a reward or a penalty is employed. Stated in terms of the operant-conditioning paradigm, the desired response is either positively or negatively reinforced by employing continuous or variable patterns of reinforcement.

Everett et al[3] employed positive reinforcement in the form of tokens distributed to riders on a campus bus, which could be redeemed for additional rides or a choice of merchandise. Deslauriers and Everett[4] extended this research by the use of variable reinforcement, and found that the distribution of tokens to every third passenger was equally effective but somewhat more cost-effective.

Other transportation-related examples using positive reinforcement were by Scheiner and Keiper[5], by Foxx and Hake[6] and by Katsev and Backman[7]. Energy-conservation examples were provided by Hayes and Cone[8] and by Winett and Neitzel[9].

Negative reinforcement was used successfully by Seaver and Patterson[10] in the form of criticisms directed at those who used increased amounts of oil. However, Kleinknecht[11] attempted to use both positive and negative reinforcement to control the

behaviour of problem drivers, but with little success.

The use of fear as negative reinforcement has also met with mixed results. Robertson et al[12] observed no difference in seat-belt usage between an experimental group and three control groups subjected to six televised fear messages. But Rochon[13] detected significant changes in beliefs about seat-belt usage after a similar television campaign. An energy-conservation application of fear by Hass et al[14] found that intentions to conserve energy could be affected by manipulating the adverse consequences of the energy crisis.

Setting gasoline prices which are intended to reduce consumption is a conservation action based on the compliance process. Olsen and Goodnight[15] provided an extensive review of the successful applications and the problems created by this approach to conservation. In particular, it is necessary to distinguish between the long-term price elasticity which may be large, and the short-term price elasticity which may be small. Willenborg and Pitts[16] argued that the reason for the short-term lack of effectiveness was that consumers adapted to changing price levels by a process of attitudinal and behavioural adjustment, rather than by reducing their driving.

Reliance on the compliance process to implement social change has a lot of intuitive appeal, especially among the unsophisticated. Implicit in the popular phrase "the carrot or the stick" is the notion that these two forms of compliance exhaust the set of alternatives. In addition, there is ample

evidence that under certain circumstances the compliance process can be very effective in bringing about a short-term behavioural change.

However, two caveats should be recognized when evaluating this process. First, a system of enforcement or reinforcement is essential to the successful use of the compliance process. When positive reinforcement is used the reinforcement schedule must not be terminated or the changed behaviour will cease. Thus, bus ridership returned to baseline conditions when Everett et al[17] ended the distribution of tokens. Foxx and Hake[18] found that mileage returned to the original levels after the winning of prizes was discontinued. When negative reinforcement is used it is necessary to adopt an effective system to minimize violations. Thus, in the priority-lane experiment described by Tischer and Shea[19], it was necessary to adopt enforcement procedures to prevent unauthorized vehicles from using the priority lanes. But success is not guaranteed even when the enforcement systems are effective. In the priority-lane experiment, there was so much public resentment by those commuters who were forced to wait in the regular crowded lanes, that eventually the priority-lanes had to be converted to regular use.

The need for enforcement and reinforcement systems does not invalidate the use of the compliance process. But it does reduce its cost-effectiveness, and this should be taken into account when evaluating programs which are based on the

compliance process.

The second caveat is that the use of extrinsic motivation can undermine any latent tendency for intrinsic motivation. Thus, reward-contingent behaviour such as conserving energy in response to cash payments, can diminish the incentive to conserve for its own sake. After reviewing a wide range of studies where this type of behaviour was manifest, Condy[20] reported:

> Compared to non-rewarded subjects, subjects offered a task-extrinsic incentive choose easier tasks, are less efficient in using the information available to solve novel problems, tend to be answer oriented and more illogical in their problem-solving strategies. They seem to work harder and produce more activity, but the activity is of a lower quality, contains more errors, is more stereotyped and less creative than the work of comparable non-rewarded subjects working on the same problems. Finally, to return to the point of departure, subjects are less likely to return to a task they at one time considered interesting after being rewarded to do it. The facts appear true of a wide range of subjects doing a wide range of tasks... and extend to effects on the process as well as the products of the task activity to the willingness of the subject to undertake the task at a later date.

The Internalization Process

This process assumes that man is a rational being who will follow his enlightened self-interest once it has been revealed to him. Implementation typically consists of a program of communications to explain the logic of the proposed change, including how the change will appeal to the target group which is expected to adopt it. While the emphasis is on information campaigns to "educate" the target group, variations also provide supplementary messages such as feedback regarding actual behaviour. The process implicitly assumes that acquisition of the information will result in favourable beliefs and attitudes regarding the change, and that this will lead to a corresponding change in behaviour.

The results reported from attempts to use the internalization process have been a mixture of partial successes and outright failures. Regarding attempts to change beliefs and attitudes, Phillips and Nelson[21] found that the "Save it" campaign in the U.K. was successful in changing beliefs in energy conservation methods, but unsuccessful in changing attitudes towards the importance of energy-related savings. Transport Canada[22] claimed success in increasing the level of knowledge about drinking-and-driving laws. Rochon[23] reported that an informational campaign resulted in changed beliefs concerning the consequences of not using seat-belts. However, Olsen and Goodnight[24] reported that in spite of all of the information disseminated to the public concerning the 1973-74

energy shortage, only 20 per cent of the public had greater awareness of the energy problem or of the need to conserve energy. One possible reason for these differences is that it is easier to gain acceptance for new beliefs and attitudes than it is to change existing beliefs and attitudes.

The results of attempts to change behaviour using the internalization process have also been equivocal. Mendelsohn[25] reported success with a multi-media campaign to persuade people to enroll in a driver-improvement program. Similarly, Fhaker and Hane[26] claimed success with respect to seat-belt usage. However, studies by Hayes and Cone[27] and by Winnett and Neitzel[28] reported that energy information had no effect on electrical usage. And according to Robertson et al[29]"....carefully controlled studies of advertising campaigns find no effect on (seat-) belt use".

In appraising the relative success of the internalization-based studies, it is interesting to note that some of the more successful studies incorporated an element of interpersonal interaction or personalized communications. Three such variations have been recognized in the literature, which are called prompting, feedback, and social labelling.

Prompting involves the use of brief messages delivered intermittently to serve as reminders. Studies by Palmer et al[30], by Delprato[31] and by Luyben[32] described the successful use of prompting to encourage energy conservation. The prompts consisted of messages left at doorsteps or beside light switches.

Feedback consists of supplying ongoing information about current behaviour. Studies by Russo[33] and by Seligman and Darley[34] reported that reductions in household electricity consumption were achieved in this way. Public uses of feedback were described by Rothstein[35] for television reports on gasoline consumption, and by VanHouten et al[36] for highway-sign reports on speeding behaviour.

Social labelling carries the feedback approach one step further by telling the target of the change attempt that he is the kind of person who engages in the desired behaviour. No energy-related applications have been reported. However, the method was found to be effective in an anti-littering study by Miller et al[37], and in a charitable giving study by Kraut[38].

On the basis of the various studies reported in this section, the internalization process seems to require great care in designing an effective program. Success seems more likely where the objective is simply to create awareness than where beliefs, attitudes or behaviour are to be changed. Successful programs which employed the internalization process tended to combine it with some other change mechanism. In the words of Olsen and Goodnight[39] after their review of the energy-conservation literature:

> Hence public education and persuasion programs may help to pave the way for more direct conservation strategies by building a climate of favourable public opinion, but once again these approaches do not appear to be adequate by themselves as a means of promoting widespread energy conserving practices.

The Identification Process

This process recognizes that social behaviour can also be influenced by socio-cultural norms, which gain their support from the attitudes and values prevalent in society. It is not enough to provide the target of the change with information about the proposed change. His attitudes must also be re-orientated before the influence will be accepted. According to Kelman[40] this can occur when the target adopts behaviour associated with another person who is admired or liked, because this results in a self-defining relationship to the person. The fact that the relationship may be known only to the target does not diminish the satisfaction which he derives from emulating the behaviour of the other person.

The focus of the identification process is on attitudinal change. Implicit in the process is the assumption that this will lead to behavioural change.

Applications of the identification process within the literatures of energy conservation or transportation are not well documented. But there are a few examples in the general literature of social change. Greenstein[41] exposed student teachers to the values of teachers classified as either "good" or "mediocre" teachers. Not only did subsequent testing reveal that the student teachers significantly changed their value system (attitude) to match the"good" teachers but they also rated them significantly higher on behavioural measures of teaching ability. Similar results were reported by Grube et al[42],

Powell and Miller as cited in Sternthal and Craig[43], Moschis[44], and Burnbrant and Cousineau[45].

One of the implications of the identification process is that those who would bring about attitude change should identify the role models and reference groups which are likely to be emulated by people in the target group. Casual empiricism suggests that some of the mass media appeals on behalf of causes such as conservation are expressed by celebreties. For example, Turner and Arnold[46] described the use by British Rail of a well-known TV personality who became their spokesman.

While the identification process seems promising for bringing about attitude change, the assumed connection to behaviour is tenuous at best. Within the domain of energy conservation, Olsen and Goodnight[47] concluded: "The vast bulk of the research evidence, therefore clearly supports the conclusion that energy attitudes and beliefs do not determine whether or not a person actually practices conservation."

Although the assumptions underlying the identification process are quite different from those of the internalization process, it encounters a similar lack of effectiveness in bringing about behavioural change. The strength of the identification process is its ability to create a climate of acceptance and thereby facilitate the implementation of more direct change efforts.

The Consistency Process

This process assumes that people strive to maintain a balance or consistency between their voluntary behaviour and their attitudes which are related to that behaviour. A change program which is based on the consistency process first tries to elicit a nominal behaviour which the change target will view as voluntary. Subsequently, the target undergoes an attitude change in favour of the behaviour, in order to restore the attitude-behaviour consistency. To complete the change program, the target is then asked to perform a more substantial behaviour.

The rationale explaining the consistency process has its roots in the cognitive dissonance tradition as exemplified in research by Festinger and Carlsmith[48], and in more recent experiments in "forced compliance" such as that by Reiss and Schlenker[49]. Most of this research has focussed on the attitude change following the voluntary behaviour. In general, a significant attitude change has been demonstrated.

Completing the consistency process by eliciting the second behaviour was called the foot-in-the-door technique by Freedman and Fraser[50]. Other applications based on the process were by Pliner et al[51], by Scott[52], by Tybout[53], by Snyder and Cunningham[54], and by Baron[55]. While these studies indicated that the consistency process can be very effective in changing behaviour, it is unfortunate for present purposes that they did not involve the conservation of transportation energy. A transportation-related study which employed the process was described by

Mendelsohn[56]. Viewers of a television program completed a test involving safe driving. Subsequently, 35000 drivers signed up for a safe-driving course, a number much larger than those who had responded to earlier appeals of a different type.

Applications of the consistency process were without exception successful in changing attitudes and beliefs. The introduction of a prior request, in which compliance to that request could be easily attributed to the individual, led to a subsequently obtained desired target behaviour.

Disadvantages of the consistency approach can only be evaluated within a specific application. Obviously, however, one disadvantage is the need for two separated interactions with the target population. The cost of this extra step must be weighed against the benefits of obtaining the eventual desired behaviour.

The other disadvantage might be a difficulty in determining the nature of the initial request. While ingenuity might be the only answer, it is useful to note that in the original study by Freedman and Fraser[57] the nature of the initial request was often only distantly or not at all related to the eventual behaviour. Others, including Varela[58] have commented upon this feature. Overall, the consistency approach to implementation of transportation energy conservation appears to hold much promise.

Programs of Social Change

The prospective designer of a program for bringing about change in the field of transportation energy conservation might well ask which of the four change processes should form the basis for the program. Among the characteristics noted in the preceding sections are some which could prove to be advantageous in some situations but disadvantageous in others. The purpose of this section is to summarize those characteristics which contribute to the relative effectiveness of programs based on the four change processes. Four criteria can be used to compare the processes: speed of response, scope of coverage, type of response, and complexity.

Speed of response. If a rapid behavioural response is required the compliance process is the most effective. This is particularly true if negative reinforcement is used, as in the case of new legislation to impose a tax on gasoline. The internalization process provides the slowest response since it relies on the gradual changing of beliefs through the dissemination of information.

Scope of coverage. The internalization process and the identification process are adaptable to the use of the mass media. Large numbers of people can be exposed to new information or endorsements in a comparatively short time. In contrast, the consistency process is best implemented through interpersonal contact which necessitates coverage of a more limited scope.

Type of response. The primary focus is behaviour with the compliance process, attitude with the identification process, and belief or awareness with the internalization process. The consistency process involves changes in both behaviour and attitude which may account for its relative effectiveness.

Complexity. The internalization and identification processes are the simplest in concept. The consistency process requires two interactions, which makes it the most complex to implement. The compliance process is conceptually simple, but the need for enforcement and reinforcement systems can also make it complex to implement.

To return to the problem of designing an effective change program, it is clear that no single change process is superior to the others in terms of all of the criteria. The best one to use in a particular situation depends on the circumstances.

Additional guidance might be sought from past empirical studies which have employed one or more of the change processes. Unfortunately, relatively few comparative studies have been undertaken. Bachman and Katzev[59] provided compliance-based and consistency-based motivations for different groups of city bus riders. While each type of motivation was more effective than the control group, there was no clear superiority of one type over the other. Tybout[60] found that consistency was at least as effective as internalization in a non-transportation context. Hayes and Cone[61] concluded that the use of feedback made the

internalization process more effective, while Miller et al[62] reached a similar conclusion regarding the use of social labelling.

The issue of which influence process is the most effective may be of hypothetical importance only. In practice, it seems that the most effective change programs are based on more than one process. Thus, the successful program to sign up people for a safe-driving course as described by Mendelsohn[63], employed methods based on both the internalization and the consistency processes. Similarly, the U.K. energy conservation program described by Phillips and Nelson[64] was based on the internalization and compliance processes. Other successful change programs based on more than one process were described by Levy[65], by Geller et al[66], by Horsley[67], and by Gardom[68].

The challenge of developing successful change programs for transportation energy conservation is threefold. First, it is necessary to understand how people in the target groups reach the decisions which determine their transportation-energy consumption. Second, the program designer must decide which of the processes of social change best describe the way those decisions are reached. Third, drawing upon our understanding of the appropriate process(es), the designer can then choose the elements of the change program keeping in mind the four criteria discussed in the preceding paragraphs.

FOOTNOTES

1. See Herbert C. Kelman, "Process of Opinion Change", Public Opinion Quarterly, 25, (1961), pp. 57-78.; Garth N. Jones,"Strategies and Tactics of Planned Organizational Change: Case Examples in the Modernization Process of Traditional Societies", in eds. Gerald Zaltman, Philip Kotler and Ira Kaufman, Creating Social Change (New York: Holt Rinehart and Winston Inc., 1972); Richard E. Walton, "Two Strategies of Social Change and Their Dilemmas", in eds. Fred M. Cox, John L. Erlich, Jack Rothman, and John E. Tropman, Strategies of Community Organization: A Book of Readings (Illinois: FE. Peacock Publishers, Inc., 1970); Robert Chin and Kenneth D. Benne, "General Strategies for Effecting Changes in Human Systems," in eds. Gerald Zaltman, P. Kotler, and I. Kaufman, Creating Social Change (New York: Holt, Rinehart and Winston, Inc., 1972); Gerald Zaltman and Robert Duncan, Strategies for Planned Change (New York: John Wiley and Sons, Inc., 1977); Jagdish N. Sheth and Gary L. Frazier, "A Model of Strategy Mix Choice for Planned Social Change", Journal of Marketing, 46, (Winter 1982), pp. 15-26.

2. Michael Ray, "Attitude As Communication Response" in eds. Deborah Johnson and William D. Wells, Marketing Research Techniques Series 17: Attitude Research At Bay (Chicago: American Marketing Association, 1976).

3. Peter B. Everett, Scott C. Hayward and Andrew W. Meyers, "The Effects of a Token Reinforcement Procedure on Bus Ridership", Journal of Applied Behavior Analysis, 7, (1974), pp. 1-9.

4. Brian C. Deslauriers and Peter B. Everett, "Effects of Intermittent and Continuous Token Reinforcement on Bus Ridership, Journal of Applied Psychology, 62, (1977), pp. 369-375.

5. J.I. Scheiner and S.A. Keiper "Car Pool Information Project: Innovative Approaches Improve Results", Transportation Research Record, 619 (1976), pp. 16-18.

6. R.M. Foxx and D.F. Hake "Gasoline Conservation: A Procedure for Measuring and Reducing the Driving of College Students", Journal of Applied Behavior Analysis, 10, 1, (Spring, 1977), pp. 61-74.

7. Richard Katzev and Wallace Bachman, "The Effects of Deferred Payment and Fare Manipulations on Urban Bus Ridership, Journal of Applied Psychology, 67, 1, (1982), pp. 83-88.

8. Steven C. Hayes and John D. Cone, "Reducing Residential Electrical Energy Use: Payments Information and Feedback, Journal of Applied Behavior Analysis, 10, (Fall, 1977), pp. 425-435.

9. Richard A. Winett and Michael T. Neitzel, "Behavioral Ecology: Contingency Management of Consumer Energy Use, American Journal of Community Psychology, (1975).

10. W. Burleigh Seaver and Arthur H. Patterson, "Decreasing Fuel Oil Consumption Through Feedback and Social Commendation", Journal of Applied Behavior Analysis, 9, (Summer, 1976), pp. 147-152.

11. Ronald Arthur Kleinknecht, "Behavior Modification of Problem Drivers", Report 024, Washington State Department of Motor Vehicles, Research and Technology Office of the Director, (December 1969).

12. Leon S. Robertson, Albert B. Kelley, Brian O'Neill, Charles W. Wixom, Richard S. Eiswirth and William Hadden, Jr., M.D., "A Controlled Study of the Effect of Television Messages on Safety Belt Use", American Journal of Public Health, 69, (November, 1974), pp. 1071-1080.

13. J. Rochon, "An Evaluation of the Seat Belt Education Campaign", Transport Canada, Report No. TP977 CR7707, (April 1977).

14. Jane W. Hass, Gerrold S. Bagley and Ronald W. Rogers, "Coping with the Energy Crisis: Effects of Fear Appeals upon Attitudes Toward Energy Conservation", Journal of Applied Psychology, 60, (1976) pp. 754-756.

15. Marvin E. Olsen and Jill A. Goodnight, "Social Aspects of Energy Conservation", U.S. Department of Commerce. National Technical Information Service - PB -266 029, (Report No.:NEPP 1-B).

16. John F. Willenborg and Robert E. Pitts, "Gasoline Prices: Their Effect on Consumer Behavior and Attitudes", Journal of Marketing, 41, (January, 1977), pp. 24-31.

17. Everett et al, "Token Reinforcement".

18. Foxx and Hake, "Gasoline Conservation".

19. Mary Lynn Tischer and Carl G. Shea, "Attitude-Behavior Changes in a Before-After Mode Choice Situation", Advances in Consumer Research, Proceedings, Eighth Annual Conference, Association for Consumer Research, (1977), pp. 456-464.

20. John Condy, "Enemies of Exploration: Self-Initiated Versus Other-Initiated Learning", Journal of Personality and Social Psychology, 35 (July 1977), pp. 459-477.

21. Nick Phillips and Elizabeth Nelson, "Social Marketing: The "Save It" Campaign", Advertising Quarterly, (Spring, 1977).

22. Transport Canada, "The Edmonton Study", Information Canada, 171 Slater Street, Ottawa, (1973).

23. Rochon, "Seat Belt".

24. Olsen and Goodnight, "Social Aspects".

25. H. Mendelsohn, "Some Reasons Why Information Campaigns Can Succeed", Public Opinion Quarterly, 37, (1973), pp. 50-61.

26. Gunilla Fhaker and Monica Hane, "Seat Belts: Changing Usage by Changing Beliefs", Journal of Applied Psychology, 60 (1975), pp. 589-598.

27. Hayes and Cone, "Reducing Residential".

28. Winnett and Neitzel, "Behavioral Ecology".

29. Robertson et al, "Television Messages".

30. Michael H. Palmer, Margaret E. Lloyd, and Kenneth E. Lloyd, "An Experimental Analysis of Electricity Conservation Procedures", Journal of Applied Behavior Analysis, 10, (Winter, 1977), pp. 665-671.

31. Dennis J. Delprato, "Prompting Electrical Energy Conservation in Commercial Users", Environment and Behavior, 9, (September, 1977), pp. 433-440.

32. Paul D. Luyben, "Effects of Informational Prompts on Energy Conservation in College Classrooms", Journal of Applied Behavior Analysis, 13, 4 (Winter, 1980), pp. 611-617.

33. J. Edward Russo, "A Proposal to Increase Energy Conservation Through Provision of Consumption and Cost Information to Consumers", Contemporary Marketing Thought. Proceedings of the 1977 Educators' Conference, American Marketing Association, (1977), pp. 437-442.

34. Clive Seligman and John M. Darling, "Feedback as a Means of Decreasing Energy Consumption", Paper Presented at the 1976 Annual Meeting of the American Sociological Association, cited in Marvin E. Olsen and Jill A. Goodnight, "Social Aspects of Energy Conservation", U.S. Department of Commerce, National Technical Information Service PB-266-029 - Report No. NEPP 1-8.

35. Robert N. Rothstein, "Television Feedback Used to Modify Gasoline Consumption", Behavior Therapy, 11, (1980), pp. 683-688.

36. Ron VanHouten, Paul Nan and Zopito Mariui, "An Analysis of Public Posting in Reducing Speeding Behavior on an Urban Highway", Journal of Applied Behavior Analysis, 13, 3 (Fall, 1980), pp. 383-395.

37. R.L. Miller, P. Brickman and D. Bolan, "Attribution Versus Persuasion as a Means of Modifying Behavior", Journal of Personality and Social Psychology, 31, (March, 1975), pp. 430-441.

38. R.E. Kraut, "Effects of Social Labelling on Giving to Charity", Journal of Experimental Social Psychology, 9, (1973), pp. 551-562.

39. Olsen and Goodnight, "Social Aspects".

40. Herbert C. Kelman, "Process of Opinion Change", Public Opinion Quarterly, 25, (1961), pp. 57-78.

41. Theodore N. Greenstein, "Behavior Change Through Value Self-Concentration: A Field Experiment", Journal of Personality and Social Psychology, 34, (1976), pp. 254-262).

42. Joel W. Grube, William L. Ranlin, Theodore N. Greenstein, and Kathleen A. Kearney, "Behavior Change Following Self-Confrontation: A Test of the Value-Mediation Hypothesis", Journal of Personality and Social Psychology, 35, (1977), pp. 212-216.

43. Brian Sternthal and C. Samuel Craig, "Fear Appeals: Revisited and Revised", Journal of Consumer Research, 1, (December, 1974), pp. 22-34.

44. George P. Moschis, "Social Comparison and Informal Group Influence", Journal of Marketing Research, 13, (August 1976), pp. 237-243.

45. Robert E. Burnbrant and Alain Cousineau, "Informational and Normative Social Influence in Buyer Behavior", Journal of Consumer Research, 2, (December, 1975), pp. 206-215.

46. Ronald E. Turner and Stephen J. Arnold, "Planned Social Change: Some Implications for Marketing", Queen's University Working Paper 81-19 (November 1981), presented at the 1982 Special Educator's Conference of the American Marketing Association, San Antonio Texas.

47. Olsen and Goodnight, "Social Aspects".

48. L. Festinger and J.M. Carlsmith, "Cognitive Consequences of Forced Compliance", Journal of Abnormal and Social Psychology, 58, (1959), pp. 203-210, cited in Harold H. Kassarjian and Thomas S. Robertson, Perspectives in Consumer Behavior. (Glenview, Illinois: Scott Foresman and Company, 1968).

49. Marc Riess and Barry R. Schlenker, "Attitude Change and Responsibility Avoidance as Modes of Dilemma Resolution in Forced - Compliance Situation", Journal of Personality and Social Psychology, 35, (1977), pp. 21-30.

50. Johnathan L. Freedman and Scott C. Fraser, "Compliance Without Pressure: The Foot-in-the-Door Technique", Journal of Personality and Social Psychology, 4, (1966), pp. 195-202.

51. P. Pliner, H. Hart, J. Kohl and D. Saari, "Compliance Without Pressure. Some Further Data on the Foot-In-The-Door Technique", Journal of Experimental Social Psychology, 10, (January, 1974), pp. 17-22.

52. Carol A. Scott, "Modifying Socially-Conscious Behavior: The Foot-in-the-Door Technique", Journal of Consumer Research, 4, (December, 1977), pp. 156-164.

53. Alice M. Tybout, "Relative Effectiveness of Three Behavioral Influence Strategies as Supplements to Persuasions in a Marketing Context", Journal of Marketing Research, 15, (May, 1978), pp. 229-242.

54. Mark Snyder and M.R. Cunningham, "To Comply or Not Comply: Testing the Self-Perception of the Foot-in-the-Door Phenomenon", Journal of Personality and Social Psychology, 31, (January 1975) pp. 64-67.

55. R.A. Baron, "The Foot-in-the-Door Phenomenon: Mediating the Effects of Size of First Request and Sex of Requester", Bulletin of Psychonomic Society, 2, (August, 1973), pp. 113-114.

56. Mendelsohn, "Some Reasons".

57. Freedman and Fraser, "Compliance Without Pressure".

58. Jacobo A. Varela, Psychological Solutions to Social Problems: An Introduction to Social Psychology (New York: Academic Press, 1971).

59. Wallace Bachman and Richard Katzev, "The Effects of Non-Contingent Free Bus Tickets and Personal Committment on Urban Bus Ridership", Transportation Research A, 16A, 2, (1982), pp. 103-108.

60. Tybout, "Relative Effectiveness".

61. Hayes and Cone, "Reducing Residential".

62. Miller et al, "Attribution Versus Persuasion".

63. Mendelsohn, "Some Reasons".

64. Phillips and Nelson, "Social Marketing".

65. G. Levy, "Participation Could Undermine Public Support", Recreation Canada, No. 34/1/76, pp. 41-47.

66. E. Scott Geller, John C. Farris and David S. Post, "Prompting as Consumer Behavior for Pollution Control", Journal of Applied Behavior Analysis, 6, (Fall, 1973), pp. 367-376.

67. A. Doyne Horsley, "The Effects of a Social Learning Experiment on Attitudes and Behavior Toward Environmental Conservation", Environment and Behavior, 9, (September, 1977), pp. 349-384.

68. G.B. Gardom, "Drinking Driving Counterattack: Summary Report to the Insurance Corporation of British Columbia Concerning the First Seven Months of the Counterattack Program", Unpublished Report, Ministry of the Attorney-General, Province of British Columbia, February 22, 1978.

STRATEGY DEFINED

A strategy consists of

- a transportation energy conservation action
- directed to a specific segment of the public
- based on a particular process of social change

TRANSPORTATION ENERGY CONSERVATION ACTIONS

1. encourage the purchase of fuel-efficient vehicles
2. provide grants to retire operable inefficient vehicles
3. provide information on energy conservation methods
4. improve vehicle maintenance through inspections
5. improve vehicle operator driving procedures
6. encourage drivers to observe maximum speed limits
7. reduce the number of working days each week

ENERGY CONSERVATION SEGMENTS

(From most promising to least promising)

age of user

household characteristics

education of user

occupation of user

income of user

dwelling measures

attitudes of user

sex of user

PROCESSES OF SOCIAL CHANGE

- compliance
- internalization
- identification
- consistency

CRITERIA FOR EVALUATING STRATEGIES

- effectiveness
- efficiency
- integrity

ACTION

encourage purchase of fuel-efficient vehicles

SEGMENT

purchasers of new cars for private use

PROCESS

compliance based on grant, low-interest loan, or income-tax incentive

DEMONSTRATION

comparison of new-car registrations before and after providing compliance incentive in different test and control areas

ACTION

provide grants to retire operable inefficient vehicles

SEGMENT

registered owners of specified vehicle types

PROCESS

compliance based on contingent grant graduated according to difference in fuel ratings of retired vehicle and replacement vehicle

DEMONSTRATION

comparison of new-car registrations before and after providing compliance incentive in different test and control areas

ACTION

provide information on energy conservation methods

SEGMENT

travellers living in specified urban areas

PROCESS

internalization based on a comprehensive information program including feedback on actual fuel consumption of the urban area

DEMONSTRATION

comparison of fuel consumption of test and control cities before and after the information program, on the basis of a continuing audit of fuel sales from a sample of outlets

ACTION

improve vehicle maintenance through inspections

SEGMENT

operators of truck and taxi fleets

PROCESS

compliance based on mandatory testing of vehicle emissions, and internalization/consistency based on voluntary testing

DEMONSTRATION

cooperating fleets are randomly assigned to either a control status, a voluntary testing status, or a mandatory testing status; fleet fuel consumption is measured before and after

ACTION

improve vehicle operator driving procedures

SEGMENT

vehicle operators associated with specific fleets of taxis, trucks, or other vehicles

PROCESS

internalization based on federally-sponsored course on driving procedures to reduce fuel consumption

DEMONSTRATION

fleet fuel consumption is measured before and after test fleets are exposed to the course, and compared with consumption of control fleets

ACTION

encourage drivers to observe maximum speed limits

SEGMENT

vehicle operators on selected highway segments

PROCESS

combined internalization and consistency based on successive requests to observe the posted maximum speed limits, and on feedback regarding ongoing results

DEMONSTRATION

controlled-access highways are designated to receive either the internalization/consistency treatment or the compliance treatment using police enforcement; speed and fuel sales are monitored

ACTION

reduce the number of working days each week

SEGMENT

employees in selected organizations

PROCESS

internalization based on informing employees of the opportunity to conduct five days of work in four days each week

DEMONSTRATION

transportation diaries maintained by participating employees are compared before and after the change

TRANSPORTATION ENERGY CONSERVATION STRATEGIES

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TRANSPORTATION ENERGY CONSERVATION STRATEGIES

Introduction

The basis for this chapter was presented in the preceding chapters. Chapter 2 presented the results of a literature review of transportation energy conservation actions - specific steps which individual travellers, private sector companies or public sector organizations could undertake to conserve energy in the movement of travellers or materials. In total, over 200 separate actions were identified, grouped according to the subject of focus of the action as follows:

- o Land development
- o Business and commerce practice
- o Work activities
- o Nonwork activities
- o Transportation energy conservation information
- o Trip management
- o Mass transit
- o Ridesharing and paratransit
- o Motorcycles, motorscooters and mopeds
- o Bicycles and pedestrians
- o Automobiles
- o Fuel prices and restrictions
- o Roads and highways, and
- o Goods movement

On the basis of the analyses in the literature and estimated energy savings, it was concluded that actions concerned with the manufacturing, sales and operations of automobiles and trucks were at a first priority level in terms of further study and possible implementation. At a second level of priority were actions concerned with informing travellers and promoting the more energy efficient alternatives. The third priority level included work-related actions and fuel prices. At the fourth priority level were actions related to the construction of roads and highways and traffic management.

Chapter 3 was concerned with the identification of target segments for the application of transportation energy conservation actions. Different members of the populations against which conservation actions are directed tend to react differently to attempts to change their behaviour. If these tendencies are strong enough, it may be worthwhile to recognize them formally by partitioning the public into segments which are internally homogeneous and externally heterogeneous. The program designer can then deliver different versions of the program to the different segments. Presumably, this will increase the effectiveness of the program's impact in each segment, as compared with the alternative of using a common program design for everyone.

A review was made of the relevant findings from the energy conservation and transportation literatures, respectively. Com-

parisons were made between the various segmentation bases using as criteria frequency of mention and the strength of the relationship with various measures of energy consumption, energy conservation and transportation behaviours. It was concluded that a tentative rank-ordering of the segmentation bases (from most to least promising) is as follows:

- o Age
- o Household characteristics
- o Education
- o Occupation
- o Income
- o Dwelling measures
- o Attitudes, and
- o Sex

Chapter 4 was concerned with how various actions could be implemented. To choose appropriate methods for implementing conservation actions, it is necessary to understand the processes by which social change occurs. Thus, the objectives of this chapter were to identify and explain the principal types of change processes, and also to review the relevant literatures for examples of their implementation.

A review of the social change literature suggested that there are four basic types of change processes:

- o Compliance - the desired behaviour is extrinsically motivated through a reward or penalty.

- o Internalization - a change in understanding is intrinsically motivated by providing information associating the change with relevant values.

- o Identification - a change in understanding is extrinsically motivated on the basis of a desired, self-defining relationship.

- o Consistency - the desired behaviour is intrinsically motivated because it is supportive of previous nominal but voluntary behaviours and subsequent rationalizing shifts in cognitive structures.

Transportation Energy Conservation Strategy

A transportation energy conservation action directed against a specific segment and following a particular process of social change defines a "transportation energy conservation strategy." There are clearly many possible conservation strategies and this chapter describes a promising subset, any one of which could be implemented by the responsible authorities. However, prior to full-scale implementation, a preliminary assessment is desirable, preferably in the form of an experimental field trial or demonstration project. A detailed proposal for a demonstration project will be the subject of the next and final chapter of this

report. The strategies from which the demonstration project is selected are the subject of this chapter.

As is evident from the preceding chapters, the literature on transportation energy conservation is extensive and detailed. Any one strategy could be discussed at length given the available knowledge. While this will be done in the next chapter for the selected strategy, a more preliminary discussion is provided at this point in order to guide the selection process. It is organized as follows for each strategy:

- Strategy-the transportation energy conservation action, segment(s) and process(es) of social change are described.

- Demonstration Project - A preliminary proposal is made on how the field experiment might be conducted.

- Effectiveness - On the basis of the available literature, an indication is provided of the potential energy savings or benefits of the conservation action.

- Efficiency - The costs which would be incurred in implementing the action on a full-scale basis are considered.

- Integrity - Desirable and undesirable effects that the strategy might have on other sectors of the economy or public are identified.

The subset of conservation strategies which appear promising enough to be further considered in a demonstration project are:

- o Encourage the purchase of energy-efficient vehicles
- o Provide grants for the trade-in and disposal of operable, fuel inefficient vehicles
- o Provide individuals with information on methods of transportation energy conservation and provide feedback
- o Improve maintenance of vehicles through inspections
- o Improve vehicle operator driving procedures
- o Maintain speed limits , and
- o Reduce the number of days in the work week

Each of these strategies is discussed in the following sections.

Although it is likely that one of the preceding subset of strategies will be assessed in the demonstration project, it should be remembered that there are many other combinations of actions, segments and change processes that could be considered. A second subset of promising actions which could form the basis for such strategies are included in the Appendix.

Encourage Purchase of Energy-Efficient Vehicles

Strategy. Individuals in the segment of private passenger vehicle purchasers are encouraged to buy energy-efficient automobiles by an incentive/disincentive based upon the fuel consumption rating. In this compliance-based strategy, the incentive would be either a grant, credit against income tax, zero interest loan or low interest loan. The disincentive would be a tax.

Demonstration Project. Separate geographic regions (cities/provinces) would be identified and randomly assigned to a control or one of the test conditions (as many conditions as there are incentives/disincentives to be assessed). Vehicle registrations in the test and control regions would be monitored before, during and after the test period. Vehicle registrations would be converted into fuel consumption ratings and the average rating for each test region compared to the control region. Energy savings, where generated, could be directly calculated.

Effectiveness. Conversion of the automobile fleet to fuel efficient vehicles is important for two reasons: first, because of the large proportion of transportation energy consumed by automobiles (approximately 50%)[1] and second, because of the relative energy efficiency of the fuel efficient automobile:[2]

Energy Consumed by the Transport Mode to Produce One Passenger-Kilometer of Service

Mode	Energy Consumption in Kilojoules per Passenger-Kilometer (kj/km)
Bus	1900
Auto (10 L/100 km)	2800
Rail rapid transit	3100
Auto (20 L/100 km)	5500

Source: Adopted from Charles A. Lave, "Conservation of Energy in the Urban Passenger Sector: A General Principle and Some Proposals," Transportation Research - A 14A (1980), pp. 322.

Numerous estimates have been made of the energy savings associated with the successful conversion of the automobile fleet:

- 9.5 percent of the total 1970 transportation energy expenditure for conversion of 50 percent of passenger cars to small cars with 12.8 L/100 km[3]

- 12 percent of total transportation energy consumed for a total 50 percent conversion to fuel economic cars[4]

- 6.4 percent highway fuel savings for a 10 percent improvement[5]

- o 21 to 24 percent energy savings in the United Kingdom for a one-third improvement in petrol consumption[6]

- o 15.3 percent of total transportation fuel for a practical 15 year limit, 14.1 L/100 km fleet average[7]

- o 34 percent energy savings for a 13.5 L/100 km vs. the 1971 20.7 L/100 km composite in the Washington, Oregon and Idaho region, and[8]

- o 40 percent reduction in automobile fuel use for a 70 percent improvement in production weighted mpg by 1985 (12.3 L/100 km).[9]

Relative to the energy savings associated with conservation actions in other sectors, these proportions are large and substantial.

Of the specific incentives/disincentives to be associated with this strategy, there is only one savings estimate: a graduated tax depending upon car engine size would achieve "perhaps about 2 %, up to 8 %".[10]

The precedent of using incentives to encourage energy conservation in Canada is well-established. In the home energy sector, the Canadian Home Insulation Program (CHIP) pays 100 percent of the cost of materials up to $350 and one-third of the labour costs up to a maximum of $150. The Canadian Oil Substitution Program (COSP) will

pay up to $800 for converting a furnace off oil to a substitute energy source.

Efficiency. A strategy involving incentives will incur costs according to the nature of the incentive. Program administration costs will also be incurred. The latter costs and potential for fraud should be relatively low, however, given that the recipient of the program need only provide proof of registration.

Integrity. This strategy would likely act as a stimulant to automobile sales. These benefits could be further focused if the program was restricted to purchasers of the domestic product.

Provide Grants for the Trade-In and Disposal of Operable, Fuel Inefficient Vehicles

Strategy. Members of the segment of registered owners of operable vehicles will be paid a graduated grant if they trade-in and scrap a vehicle rated as consuming more than a specified L/100 km of gasoline. They will be required to purchase a new vehicle consuming less than a second specified L/100 km of gasoline. The grant in this compliance-type strategy increases in proportion to the fuel consumption rating of the vehicle traded-in and in inverse proportion to the rating of the vehicle purchased in its place.

Demonstration Project. Separate geographic regions (cities/provinces) would be identified and randomly assigned to either the test condition or a control status. The success of the strategy would be determined through comparison of vehicle registration records in the test and control regions prior, during and subsequent to the project. Retrospective questioning of a sample of owners and dealers would also be made.

Effectiveness. This strategy supports the general objective of converting the automobile fleet to fuel efficient vehicles. In this regard, the discussion and energy savings estimates provided for the previous strategy, "Encourage Purchase of Energy-Efficient Vehicles," are applicable. Of specific relevance is the estimate that 2300 L of gasoline would be saved if a 28 L/100 km vehicle, otherwise driven 16 000 km, was scrapped and replaced with a 14 L/100km vehicle.[11]

Efficiency. This strategy would incur the costs of the grants and supporting administrative costs. It would also be subject to misrepresentations and fraudulent behaviour (inoperable vehicles made operable for receipt of the grant; vehicles not scrapped). An advantage of the strategy is that the program would automatically end when all fuel inefficient vehicles were traded in.

Integrity. This strategy could serve to stimulate automobile sales, although there would likely be disproportionate income effects. New car purchasers[12] tend to have higher incomes and conversely, owners of the older, fuel inefficient cars may be from the lower income groups. These two characteristics may tend to limit the success of the program or at least restrict its adoption to members of the higher income groups.

An advantage of a successful program is that it should increase road safety. Older, and possibly less safe vehicles would be taken off the road sooner than would normally occur.

Provide Individuals with Information on Methods of Transportation Energy Conservation and Provide Feedback

Strategy. Members of the urban traveller segment are provided with tips on conserving transportation energy in a comprehensive information program which includes:

- o Paid advertising
- o Direct mail
- o Common interest group seminars, and
- o Personalized, transportation energy conservation audits.

An important feature of this internalization-type strategy is that paid advertising and direct mail are used to continuously inform residents in the urban area of the level of transportation consumption. This feedback is provided with the conservation tips which generally deal with energy efficient vehicle purchase, operation and maintenance.

Demonstration Project. Cities which can be separated from each other are randomly allocated to either the test or a control condition. A continuous audit is made of a random sample of fuel outlets in the city before, during and after the test, in order to both assess the strategy and provide the feedback information.

Effectiveness. The precedent for this strategy is found in a Midland-Odessa, Texas experiment where weekday evening television displayed graphs on daily gasoline consumption and provided conservation tips.[13] It was found that these tips and feedback through the mass media significantly reduced fuel consumption.

Support for an information strategy in general is found in a paper by Habermann who suggested accurate and simple information in order "to guide the consumer toward an eventual reassessment of value systems that prioritize the use of the private automobile."[14] Similarly, Horowitz concluded that "while incentives are required to change affect, persuasion (advertisement) is sufficient to change cognition."[15]

Support from the public for an information strategy is indicated in the results of a U.S. survey conducted in October 1974 by the Opinion Research Corporation.[16] In response to the statement that the "Federal government inform on energy conservation," it was found that 84% were in favour. In Neveu's New York State telephone survey conducted during the Fall of 1977, attitudes towards various transportation energy conservation actions were assessed.[17] The percent agreements (n=454) for the statements "Encourage people to plan trips better," "... shop closer to home" and "... shop less frequently" were 87%, 82% and 74%, respectively.

Estimates of the energy savings associated with an information strategy are not readily available which is obvious given that such

programs are generally in support of another conservation action. One such estimate is provided by Voorhees and Associates who determined that "carpool public information" would result in a 2.0 to 4.0 % regional energy reduction.[18] For the Midland-Odessa experiment reported above, the mean decrease from baseline to experimental conditions was 31.5% of gasoline consumption.[19] This author also cites other studies in which feedback reduced electrical energy use by 10 to 15% although one study reported a 35% decrease.[20]

Efficiency. Each component of the information program - advertising, direct mail, seminars and personal audits - would involve marginal costs. Administrative costs, however, would appear minimal as the advertising agency would take their commission in placing the advertising and direct mail while the seminars and audits could be contracted out.

Integrity. As indicated above, an information strategy would serve to acquaint travellers with other conservation actions and would therefore be supportive of such activities. The media and the advertising agencies would also benefit although this strategy would tend to add to an already significant public sector presence in the media.

Improve Maintenance of Vehicles Through Inspections

Strategy. Operators of truck and taxi fleets have their vehicles inspected in order to ensure that they are being properly maintained and operating at peak energy efficiencies. In some fleets, the inspection is compulsory and follows a compliance-type process. In the others, the inspection is voluntary and is based upon a combination internalization/consistency type approach.

Demonstration Project. Cooperating fleets are randomly assigned to either a control condition, a voluntary inspection condition, or a compulsory inspection condition. Fleet fuel consumption records are compared before and after the inspections.

Effectiveness. According to Orski, an improperly tuned engine penalizes energy consumption as much as 6 percent and a poorly maintained ignition system by as much as 20 percent.[21] For these reasons, annual inspections proposed for the N.Y. City metro area were considered to result in a reduction in fuel use of 10 percent for each car that failed the initial inspection.[22] Itwas considered to be the third most effective program of five energy conservation programs in the state.

Other energy savings estimates from maintenance and tune-up programs are available:

o 5.3 percent average increase in fuel efficiency from a tune-up[23]

- 3 to 9 percent savings for "having the car tuned"[24]

- 2 percent reduction in fuel consumption from a Houston maintenance program[25]

- 0.2 to 0.5 percent reduction in transportation fuel use in Illinois.[26]

Efficiency. From a theoretical perspective, a successful voluntary inspection program will be better for the long run. The danger of the compulsory inspection, consistency-type program is that it can extinguish any desire to participate in a maintenance program on a voluntary basis. Once imposed, controls must always remain in place.

The precedent for voluntary inspections in the Canadian context is provided in the current, home energy ENERSAVE program administered by the federal governement. Costs for a similar program in the transportation sector could be determined from this experience. An alternative is the N.Y. State program which calls for emissions testing at approximately 4,000 private inspection stations. To monitor performance of the private stations, the state will also construct six 2-lane monitoring stations.[27]

Integrity. This strategy will contribute to cleaner air and greater road safety. The implementation of an inspection program will also stimulate employment in the automobile and service station sector.

Improve Vehicle Operator Driving Procedures

Strategy. Vehicle operators associated with an identifiable fleet (e.g., taxi fleet, truck fleet, transit system, airline) are given a federally-sponsored course on operating/driving procedures. The course would be concerned with procedures which increase the energy usage efficiencies of the driver/operator. For example, for taxis and trucks, improved driving procedures mean smooth and moderate acceleration, driving at a steady pace, avoiding stop and go traffic, minimizing braking, not letting the motor idle for more than a minute, not overfilling the gasoline tank and removing unnecessary weight from the car.[28]

Demonstration Project. Fleets in each identifiable grouping are randomly allocated to control and experimental conditions. The fuel consumption of each fleet is monitored before and after the course.

Effectiveness. According to Milstein, improved driving habits can mean 20 percent greater fuel efficiency compared to the average driver and 50 percent more than the wasteful driver.[29] In a taxi fleet, these improved habits would help to "improve the efficiency of taxi service" which Voorhees and Associates estimated would mean a 0.2 percent regional energy reduction.[30] In an airline fleet, better operator procedures in conjunction with an improved air traffic control system would result in a 4.5 percent increase in fuel efficiency.[31]

Urban rail transit systems are also amenable to improved operator pro-

cedures involving optimal acceleration, coasting and braking. Idealized tests by the New York City Transit Authority demonstrated an 18.4 percent decrease in energy consumption.[32] Eash reported that increased coasting before brake application had "the most potential for improving energy consumption in rail transit."[33]

Efficiency. The major cost of this strategy would be for the courses which could be quite short. The benefit of the course may be as much tied to the awareness regarding energy conservation it creates as it is to the knowledge generated.

Integrity. This strategy has a minor potential for job creation. As indicated above, its major impact may be in providing a basis of support for transportation energy conservation in general.

Maintain Speed Limits

Strategy. Two change processes are implemented to reduce the speeds of private motor vehicles on intercity highways to the posted limits. The first process is compliance-based and involves strict enforcement by the police. The second process is a combination consistency and internalization-based procedure and involves progressive requests to highway travellers for decreased speeds. Signs or other information along the highways inform travellers of the average speed of all travellers and changes from the preceding period.

Demonstration Project. A group of controlled-access highways are identified and randomly assigned to one of three conditions: 1. police enforcement, 2. Progressive requests and feedback, and 3. a control where no changes are made. Fuel consumption is monitored on the gasoline stations or a sample of the gasoline stations adjacent to the highways. In addition, unobtrusive samples are made of the speeds along the highways and the vehicles involved. By referring to the fuel consumption ratings, energy savings estimates can be made. Highway accident records will also be monitored.

Effectiveness. It would be expected that the compliance-based, police enforcement procedure would show immediate effects. However, such an approach requires continuous enforcement as speeds would rise again as soon as the enforcement ended. In contrast, the consistency/ internalization-based, progressive request and feedback procedure

would be more difficult to implement, likely slower to show results, but more likely to incur long-lasting and permanent effects.

The public support for the maintenance of posted speed limits is indicated in Neveu's New York state 1977 telephone survey.[34] Among the 454 respondents, 91 percent agreed with the conservation action "enforce 55 mph limit." This level of agreement was second highest among 13 proposed conservation actions.

Estimates of the energy savings associated with reduced speeds include:

- 0 to 2 percent regional energy reduction for "reduced speed limits"[35]
- 3 percent for "reduce to 50 mph and achieve 50 percent success"[36]
- 2.8 percent for reduced speed limits[37]
- 2.9 percent saving potential for an "ultimate (50 mph)"[38]
- 3.8 percent saving for an average speed of 50 mph in the Oregon, Washington and Idaho region[39]
- 0.3 to 0.5 percent reduction in Illinois transportation fuel use for enforcement of the 55 mph limit[40]

Of particular relevance is the New York state estimate that increased enforcement of 55 mph" would lead to an estimated 1980 savings of 16.6 trillion BTU (17.5 trillion kj), the highest saving of five proposed state conservation programs.[41]

Efficiency. This strategy would incur the staff costs of a monitoring team. Increased police enforcement may involve some marginal costs. The progressive request/feedback approach would have capital costs associated with the signs and other information devices.

Integrity. This program would likely result in fewer accidents, a possibility to be confirmed by the maintenance of accident records. This program would also have spillover conservation effects on the other users of intercity highways i.e., trucks and buses.

Reduce the Number of Days in the Workweek

Strategy. Employees in departments and firms in the public and private sectors are offered the opportunity to conduct five days of work in longer, four-day weeks.

Demonstration Project. Participating firms/departments are randomly allocated to either a control condition or the experimental condition. Employees in both groups maintain productivity and transportation diaries before and after the four-day-work-week offer is made.

Effectiveness. Two energy savings estimates are:

- 0.4 to 2.6 percent reduction in Illinois transportation fuel use[42]
- 1 to 6 percent energy savings.[43]

Presumably, these estimates are based on the notion that the automoble is not being used to take the employee to work on the fifth day. However, use of the vehicle for other purposes e.g., recreational, could negate any energy savings and even increase energy usage. The effects of this strategy are also less certain because of the major social and behavioral changes that are involved. However, there is certainly precedent for longer days of work associated with longer periods of time off among blue collar shift work, particularly in remote sites.

Efficiency. Program costs for this strategy would appear minimal other than for the technical staff to explain and monitor the programs during the demonstration project. A participating firm/department, however, could experience productivity costs, a possibility to be monitored during the demonstration project.

Integrity. Successful implementation of this strategy would result in reduced demand on the transportation system over the five-day week and over peak periods. It could also impact upon business patterns.

Footnotes

1. U.S. Department of Transportation, "Energy Conservation in Transportation: Programs of the U.S. Department of Transportation," (Washington, D.C.: Secretary of Transportation, May, 1978), p.1.

2. See Eric Hirst and Mayo S. Stuntz, Jr., "Urban Mass Transit Energy Use and Conservation Potential," Energy Systems and Policy 1, No. 4 (1976), pp. 391-406 and Charles A. Lave, "Conservation of Energy in the Urban Passenger Sector: A General Principle and Some Proposals," Transportation Research-A 14A (1980), pp. 321-326.

3. A.C. Malliaris and R.L. Strombotne, "Demand for Energy by the Transportation Sector and Opportunities for Energy Conservation," in Energy Primer: Selected Transportation Topics (Cambridge, MA: Office Program Development, U.S. Department of Transportation, Transportation Systems Center, Kendall Square, Code 151, 02142, 1974), p. 42.

4. Roger E. Carrier, "Energy Conservation through Urban Transportation Planning," Transportation Research 8 (1974), p. 495.

5. Alexander French, "Transportation Energy Considerations," Transportation Engineering Journal 102 (February 1976), p. 35.

6. D. Maltby, I.G. Monteath and K.V. Lawler, "The UK Surface Passenger Transport Sector: Energy Consumption and Policy Options

for Conservation," Energy Policy, (December 1978), p. 305.

7. David Rubin, J.K. Pollard and Chris Hornig, "Transportation Energy Conservation Options (Draft)," in Energy Primer: Selected Transportation Topics (Cambridge, MA: Office of Program Development, U.S. Department of Transportation, Transportation Systems Center, Kendall Square, Code 151, 02142, 1974), p.51.

8. J. Thomas Dickinson, "Transportation and Energy Conservation in the Pacific Northwest (Pullman, Washington 99163: Physics Department and Environmental Research Center, Washington State University, Revised June 1974), p.9.

9. French, "Transportation," p. 37.

10. Maltby, Monteath and Lawler, "The UK," p. 308.

11. Edward F. Renshaw, "Recession in the US Motor Industry and the Quest for Fuel Economy," Energy Policy (March 1981), pp. 20-24.

12. Stephen J. Arnold, "Correlates of New Car Purchase: Additional Analyses of the CSD Data Base" (Kingston: School of Business, Queen's University, February, 1982).

13. Robert N. Rothstein, "Television Feedback Used to Modify Gasoline," Behavior Therapy 11 (1980), pp. 683-688.

14. Jill L. Habermann, "Consumer Reactions to the 1979 Gasoline Shortage," Transportation Research Board Special Report 191 (1980), p. 101.

15. Abraham D. Horowitz, "An Attitudinal Model of Carpooling Behavior" (Paper prepared for presentation at the Annual Meeting of the American Psychological Association, Chicago, Illinois, August 31, 1975), abstract page.

16. Harry W. O'Neill, "The Effects of Energy Availability and Costs on Consumer Attitudes and Behavior," in Mary Jane Schlinger, ed., Advances in Consumer Research Volume 2 (Ann Arbor, Michigan: Association for Consumer Research, 1975), pp. 863-878.

17. Alfred J. Neveu, "Public Opinion Survey on Energy and Transportation" (Albany, New York: Planning Research Unit, New York State Department of Transportation, December 1977), p. 17.

18. Alan M. Voorhees and Associates, Inc., "Guidelines to Reduce Energy Consumption Through Transportation Actions" in Energy Primer: Selected Transportation Topics (Cambridge, MA: Office of Program Development, U.S. Department of Transportation, Transportation Systems Center, Kendall Square, Code 151, 02142, 1974), p. 59.

19. Rothstein, "Television Feedback," p. 685.

20. Ibid., p. 683.

21. C. Kenneth Orski, "The Potential for Fuel Conservation: The Case of the Automobile," Transportation Research 8 (October 1974), p. 252.

22. The New York State Energy Office, "New York State Energy Conservation Plan 1977-1980," (Albany, New York: Agency Building 2, Empire State Plaza, USA 12223), pp. 30, 31.

23. Lave, "Conservation," p. 325.

24. Jeffrey S. Milstein, "Energy Conservation and Travel Behavior," in H. Keith Hunt, ed., Advances in Consumer Research Volume V (Ann Arbor, Michigan: Association for Consumer Research, 1978), p. 424.

25. Peter G. Rowe and Carvel W. Glenn, "Alternative Actions for Achieving Energy Savings in the Transportation Sector. Summary" Report No. UMTA -TX-11-0010-81-1 (Houston, Texas 77046: Rice Center, 9 Greenway Plaza, Suite 1900, November 1980), p.6.

26. Darwin G.Stuart and Richard J. Hocking, "Contingency Transportation Plans for Urban Areas and Their Potential Impacts," Transportation Research Record Special Report 191 (1980), p. 150.

27. The New York State Energy Office, "New York State," p. 31.

28. From Milstein, "Energy Conservation," p. 324. For references to improved truck driver procedures, see Sushil K. Bhaltacharyya, "A Framework for Urban Goods Movement Information in Canada, Volume 9," (Ottawa: TEE Consulting Services Inc. for the Urban Transportation Research Branch of Canadian Surface Transportation Administration Transport Canada, March 1979), pp. 176-183, and B. Ratcliffe and T. Fletcher, "Fuel Conservation: Much Talk but not a Lot of Action," Transport 1, no. 3 (July/August 1980), pp. 53-54.

29. Milstein, "Energy Conservation," p.324.

30. Voorhees and Associates, p. 60.

31. F. W. Gobetz and A.A. LeShane, "Cost/Benefit Trade-Offs for Reducing the Energy Consumption of Commercial Air Transportation (RECAT)," UTRC R76-912036-17 (East Hartford, Conn.: United Technologies Research Center, June 1976), p.27.

32. C.N. Viswanathan, R.W. Longman and G.A. Domoto, "Energy Conservation in Subway Systems by Controlled Acceleration and Deceleration," Energy Research 2 (1978), pp. 133-151.

33. Ronald W. Eash, "Energy Efficient Rail Transit Operation," Transportation Research Record 662 (1978), pp. 1-6.

34. Neveu, "Public Opinion Survey," p. 17.

35. Voorhees and Associates, "Guidelines," p. 60.

36. Malliaris and Strombotne, "Demand," p. 43.

37. Carrier, "Energy Conservation," p. 495.

38. Rubin, Pollard and Hornig, "Transportation Energy," p. 52.

39. Dickinson, "Transportation," p. 18.

40. Stuart and Hocking, "Contingency," p. 150.

41. The New York State Energy Office, "New York State," p. 30.

42. Stuart and Hocking, "Contingency," p. 151.

43. Voorhees and Associates, "Guidelines," p. 59.

APPENDIX

Additional Promising Transportation Energy Conservation Actions

- Provide home goods delivery
- Substitute telecommunications for travel
- Expand automobile piggy-back rail service
- Provide transit service to recreational sites.
- Encourage the formation of vanpools
- Increase the energy efficiencies of traffic management systems
- Increase truck loading and routing efficiencies
- Increase the number of walking trips
- Substitute propane for gasoline, and
- Increase fuel prices
- Conduct work at home

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AN INFORMATION STRATEGY FOR TRANSPORTATION ENERGY CONSERVATION

A Demonstration Project Proposal

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January 1983

The views presented in this paper are those of the authors and do not necessarily reflect the views or positions of the Department of C.C.A.

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1. Introduction

Seven promising strategies for conserving transportation energy were identified in the preceding chapter. Each was recommended for further consideration on the basis of written accounts in the literature of transportation energy conservation. This chapter describes the final stage in the analysis of the seven strategies. It consists of the following two parts:

i. choosing one of the seven candidate strategies for more intensive evaluation;

ii. designing a demonstration project for evaluating the chosen strategy.

The procedure which was adopted for choosing one strategy began by discussing the seven strategies with a group of government officials. The discussion revealed various reasons for discriminating between the candidate strategies, which ultimately permitted one strategy to be chosen. The results of this process and the chosen strategy are described in section 2 and section 3.

The design of the proposed demonstration project occupies the remainder of the chapter. In section 4, the overall experimental design is described. This is followed in section 5 by a description of four experimental treatments. The proposed data collection and analysis methods are described in section 6. The chapter concludes with estimates of the budget and the schedule for the demonstration project.

2. Choosing a Strategy

The seven candidate strategies were discussed on October 18, 1982 with a group of six government officials representing the federal departments of Energy Mines and Resources, Consumer and Corporate Affairs, and Transport Canada. The discussion revealed a number of factors which made certain of the strategies less promising as candidates for a demonstration project. For example, some strategies were seen as duplicating existing programs, while others seemed to be too difficult to administer. The impact of the various judgments was to progressively eliminate most of the seven strategies as promising candidates. In the following paragraphs, each of the eliminated strategies is discussed briefly. The remaining strategy, which was chosen for the demonstration project, is discussed in the next section.

The first strategy in the preceding chapter's listing was to encourage the purchase of fuel-efficient vehicles by new-car buyers through incentives like grants, loans, or tax rebates. However, any demonstration project in which this strategy is employed on a restricted basis could be seen as discriminatory. It is not clear how the principle of universality of such incentives could be maintained while testing the strategy on a limited basis. The strategy would also be controversial because of the side-effects on automobile manufacturing and importing, of any substantial diversion of demand from large to small automobiles. The issue of the relative safety of large-versus-

small cars could also make such a diversion controversial. Thus, the strategy seems ill-advised because of the potential problems created by its side-effects.

The provision of grants to encourage the scrapping of inefficient vehicles is another strategy which seems problematic. Clearly, this strategy would raise the question of the economy of scrapping operable equipment. While long-term fuel savings would be realized, they would be at the expense of short-term cash flows to finance the investment in new automobiles. The administration of such a program could also be controversial. For example, it would be necessary to reject any application based on a car which had been temporarily resurrected from the scrapyard.

The program of mandatory testing of commercial fleets seemed promising on the basis of the findings in the literature. However, the most promising application among truck fleets is already covered by federal and provincial programs. Implementation problems would be anticipated among most other commercial applications. For example, drivers of taxis tend not to change their behaviour unless motivated by the prospect of increased business. There is also some question of the cost-effectiveness of mandatory inspection programs if only a small minority are caught. The benefits from compliance may be offset by the cost and inconvenience borne by the majority who require no remedial action. One possible commercial segment which could justify scrutiny is the courier service operators.

Another promising strategy involving commercial fleets was to offer government-sponsored courses to improve driving procedures. Here also, programs exist at both the federal and the provincial levels. Thus, there is no need for a demonstration project of this type.

A related driver-improvement strategy was to increase the observance of the posted speed limits among the general public. Transport Canada has commissioned work on this strategy in the past. While the strategy still seems promising, it was felt that another demonstration project would have only marginal value.

The conversion from five working days per week to four, was seen as a promising way of reducing the amount of work-related travel. However, it seemed likely that an employer's decision to adopt this practice would be influenced by many factors which could not be controlled in a demonstration project. While it seemed worthwhile to study the incidence of such conversions and their effects on fuel conservation, a demonstration project appeared to be an inappropriate methodology. Therefore, this strategy was also eliminated from further consideration.

After ruling out the six strategies identified in the preceding paragraphs, only one of the original seven promising strategies remained. The strategy chosen for the demonstration project consists of providing information on energy conservation methods to travellers living in specified urban areas. Since the provision of information can take many forms, it is necessary to specify the scope of the proposed information strategy. That is done in the next section.

3. Information Strategy

The particular form of the information strategy which was outlined in the preceding chapter was based on the internalization process. As previously indicated, this process assumes that information which explains the logic of a desired course of action is needed in order to influence people to take that action. Included in the information would be feedback concerning the community's transportation fuel consumption, which would reinforce individual fuel-conserving behaviour.

The demonstration project should test other forms of the information strategy in addition to that which is based on the internalization process. Partly, this broadening of the meaning of the information strategy is necessary in order to provide a basis for comparison. It seems preferable to evaluate the effectiveness of information based on the internalization process compared with information based on alternative influence processes, rather than making the evaluation relative to no information.

Another reason for testing alternative forms of the information strategy is simply that there are other influence processes which seem promising, and may indeed produce a more effective information strategy than the internalization process. The three additional influence processes which were identified previously are the compliance process, the identification process and the consistency process. It is proposed that alternative information strategies based on each of these processes be tested to determine their relative effectiveness.

It should be acknowledged that the most effective information strategy could be one which is based on two or more of the four influence processes. For example, a strategy based on both the logic of conservation (internalization) and the threat of an energy shortage (compliance), could be more effective than a strategy which concentrates on only one. Unfortunately, it is infeasible to test each of the various combinations of the four influence processes. But knowledge of the relative effectiveness of the four single-process strategies should provide some guidance in evaluating the multi-process strategies. Thus, if one of the four influence processes were ineffective when used singly, it would be a poor prospect for use in combination with a more effective process.

Descriptions of the four forms of the information strategy are provided in section 5 where the experimental treatments are detailed. For present purposes, it is only necessary to identify them, as follows:

3.1 The internalization form provides information which demonstrates the logical connections between specific travel behaviours and the goal of energy conservation.

3.2 The compliance form emphasizes the payoffs to the individual; specifically, the costs of energy-wasting travel and the savings from energy-conserving travel.

3.3 The identification form provides positive role-models such as celebrities, whose energy-conserving endorsements travellers will want to emulate.

3.4 The consistency form asks travellers for minor voluntary actions, such as telephoning or mailing a coupon, in the expectation that such actions will bring about positive conservation attitudes.

4. Experimental Design

The demonstration project will be designed as a controlled experiment. This design will permit causal inferences to be drawn concerning the effectiveness of the alternative information strategies in bringing about changes in travel-related behaviour.

It is well known that field experimentation in the social sciences is potentially vulnerable to several types of experimental error. To reduce the error to tolerable levels, the experimental design will be that which is known as "randomized before-after with control." With that design, the experimental units are matched in similar pairs and randomly chosen either to receive the experimental treatment or to be a control unit which receives no treatment. Measurements are taken before and

after the administration of the experimental treatment in the experimental unit, and simultaneous measurements are taken in the control unit. Comparison of the magnitude of any before-after difference in the experimental unit with a corresponding magnitude in the control unit, leads to inferences about the effect of the experimental treatment.

The units in this design are medium-sized Canadian cities. The measurements are aggregate consumption of fuel for automobiles and other road vehicles, as sold by the commercial service stations within each city. The data-collection methods described in section 6 make it feasible to measure fuel consumption at regular intervals and at reasonable cost.

Since there are four experimental treatments, corresponding to the four information strategies, the experimental design will involve four pairs of cities. Each city pair will be matched in terms of the following criteria:

4.1 the mean level and seasonal pattern of the consumption of automobile fuel

4.2 the severity of weather conditions.

The experimental treatments will be randomly assigned to the four city pairs, and the choice of the treatment city in each pair will also be determined randomly. A cross-over design will be employed, whereby each treatment city will receive all four of the experimental treatments sequentially. Within each treatment city, the four successive treatments will be separated

by lengthy "cooling off" periods in which no experimental treatments will be employed and any carryover effects will be allowed to stabilize. Although this design makes it advisable to monitor the carryover effects of previous treatments, it also makes it possible to detect peculiarities in individual cities which were not captured in the above criteria.

Prior research suggests that the "cooling-off" period should be at least four weeks. One feasible schedule would consist of alternating a six-week treatment period and a six-week "cooling-off" period four times during the course of one year. Thus, it seems likely that seasonal changes will occur during the project, and that the design should take account of them.

The design described in the preceding paragraphs allows for most types of experimental error. One exception is interactive testing effect, which can arise in field experiments when the subjects become sensitized to the measuring instrument. Since the measurements consist of the reading of service station gauges, it seems unnecessary to include in the design protection against this type of error.

Nor does the design explicitly control the loss of subjects which is known as mortality. However, minor changes in the number of service stations should not affect consumption significantly because of the overcapacity which usually exists. At the disaggregate level, seasonal effects may cause the loss of some travellers, but this will be controlled by the statistical design which is outlined next.

The two main effects which are expected to influence the experimental outcome are the season effect and the city effect. The crossover design permits each of these effects to be appraised separately. One additional potential influence on the outcome is the interaction between the season effect and the city effect. This could be significant if each pair of experimental and control cities was separated by long distances and subject to different seasonal effects on driving conditions. By choosing city pairs which are near each other, it is expected that the interaction effect will be minimized.

The appropriate design for taking into account both the "city" effect and the "seasonal" effect is the Latin square design. Table 4.1 illustrates such a design in which the blocking variables are the city and the seasonal quarter. Note that the months included in each quarter (abbreviated in parentheses) are chosen to minimize inter-quarter differences. The measurements to be taken in cities 1 and 2 (i.e. the first column of Table 4.1) are detailed in Table 4.2. Further description of the statistical analysis of the resulting data is deferred until section 6.

In summary, the experimental design will involve monitoring aggregate automobile fuel consumption in eight cities over a period of one year. The data-collection procedures for doing this are described in section 6. In four of these cities, four different information strategies will be tested experimentally. The form of these four treatments is described next.

Table 4.1: Illustrative example of a Latin-square design*

	Cities 1 & 2	Cities 3 & 4	Cities 5 & 6	Cities 7 & 8
Quarter (F-M-A)	internalization	identification	compliance	consistency
Quarter (M-J-J)	identification	compliance	consistency	internalization
Quarter (A-S-O)	compliance	consistency	internalization	identification
Quarter (N-D-J)	consistency	internalization	identification	compliance

* in practice, the four treatments would be randomly assigned to the cells subject to the usual row and column constraints, so that the regularities in the above example would likely not occur.

Table 4.2: Illustrative example of measurements* for one city-pair

	Experimental City 1	Control City 2
Quarter (F-M-A)	B_{11}	B_{12}
	W_{11}	
	A_{11}	A_{12}
Quarter (M-J-J)	B_{21}	B_{22}
	X_{21}	
	A_{21}	A_{22}
Quarter (A-S-O)	B_{31}	B_{32}
	Y_{31}	
	A_{31}	A_{32}
Quarter (N-D-J)	B_{41}	B_{42}
	Z_{41}	
	A_{41}	A_{42}

*The code for the above symbols is:

B_{ij} = before-measure in quarter i for city j
A_{ij} = after-measure in quarter i for city j
W_{ij} = internalization treatment in quarter i for city j
X_{ij} = identification treatment in quarter i for city j
Y_{ij} = compliance treatment in quarter i for city j
Z_{ij} = consistency treatment in quarter i for city j

5. Experimental Treatments

The design of the experimental treatments requires answers to the four questions which are customarily encountered in any communications process:

Who is the intended receiver of the communication?

Which communications media will be used?

What message will be communicated?

Who is the sender of the communications?

The four treatments could be designed on the basis of different answers to each of these questions. However, the essential differences between the four influence processes which underlie the four treatments can be found in the answers to the last two of the questions. To facilitate comparisons, therefore, it seems advisable to differentiate the treatments primarily on the basis of the sender and the message. Before describing the four treatments in terms of their message-sender differences, it is necessary to comment on their communications commonalities. These arise from the answers to the first two questions.

5.1 Commonalities

Regarding the intended receiver, evidence was cited earlier which indicated that some segments of the public are more responsive to energy-conservation appeals than other segments. There is no comparable evidence that the effectiveness of the four influence processes also differs across public segments. Certain speculations could be made, for example, that travellers having

low education and income would be more responsive to the compliance process than the internalization process. However, these speculations do not provide a sufficient basis for designing the study. Another reason why it is difficult in this study to target the communications is that the choice of media is limited by the experimental conditions, as described below. Therefore, it seems necessary to direct the communications to the mass market and rely on the mechanism of self-selection for whatever differentiation may occur between the appeals of the different influence processes to different segments.

The media to be used for this experiment must satisfy the following criteria:

- specific to each treatment city
- overlap minimally with other cities
- flexible enough to accommodate each of the treatments

Newspapers satisfy the first two criteria best. Local television satisfies the third criterion best, but it is not clear how well it can satisfy the second criterion. If each pair of treatment and control cities must have similar seasonal variations, this may make it difficult to employ television.

It is proposed to use the same media plan for all treatments and all cities. Primary reliance will be placed on the local newspapers. Local television will also be used if permitted by the choice of experimental cities and control cities. The use of both media will increase the "media reach", and reduce

any bias resulting from exclusion of those who do not read newspapers, for example. Thus, besides having a common media plan, all treatments will have the same intended receivers, i.e. the mass market consisting of newspaper readers and television viewers.

5.2 Differences

The message and the sender to be used with each treatment have already been implied in the earlier discussions of the four influence processes. Little can be added at this time since the development of the message details is necessarily a large part of the demonstration project. However, the general characteristics which would differentiate the four message-sender treatments are made explicit in the following paragraphs.

The internalization treatment will provide descriptions of methods for conserving automobile fuel such as keeping tires fully inflated and having regular engine tune-ups. Aggregate fuel consumption will be reported so that conservation behaviour will be reinforced. The sender does not need to be personified, but the message should be credible and authoritative.

The compliance treatment will illustrate the cost savings which are possible when one adopts fuel-conserving behaviour. Consequences of fuel-wasting behaviour, such as fuel shortages, will also be described. Again, the emphasis should be on credibility and authoritativeness, rather than on the personality of the message sender.

The identification treatment will consist of endorsements of fuel-conserving behaviour by a well-known personality. The sender will be someone who is likeable as well as credible in the role of fuel conserver. The underlying appeal for the receiver will be to identify with the sender by adopting the recommended behaviour.

The consistency treatment will elicit a small voluntary act by the receiver. For example, the receiver may be asked to display a "conserver" bumper sticker obtained by first telephoning a listed number. The message will focus on persuading the receiver to demonstrate his support by participating. The sender may be personified, although this is not essential.

To summarize, four different experimental treatments will be communicated to the general public in the four experimental cities via local newspapers and local television. The treatments will be differentiated by the message and the sender, in accordance with the four influence processes.

6. Data and Analysis

The principal data to be collected are the fuel consumption readings at individual commercial service stations within each experimental and control city. At least one marketing research firm provides custom-designed reading schedules on the basis of 9000 urban Canadian service stations. One meter-reader can read 75 stations, the number in a typical medium-sized city, in a seven-hour period. The data can be aggregated to the city level, or various subtotals can be provided, such as brand or type of fuel.

It is proposed that this service be purchased in each of the experimental cities and control cities for the before-measures and after-measures which were shown in Table 4.2. Allowing for several additional readings to check for relative stability, this would amount to approximately 100 city-wide readings, spread over the eight cities and one-year duration of the measurement period.

Also available are ten years of past data for various cities. It is proposed that these historical data be accessed to aid in the matching of experimental and control city-pairs, on the basis of the level and pattern of past consumption.

In the first stage of the analysis, the change in consumption must be calculated in each experimental unit. Consider experimental city e and control city c. The change in consumption is defined as:

$$\dot{C} = (A_e - B_e) - (A_c - B_c)$$

where A is an after-measure and B is a before-measure.

Any observed change in consumption $\hat{C}$ is assumed to be the result of the following effects:

$$\hat{C} = \mu + \alpha + \beta + \gamma + \varepsilon$$

where μ = mean of all cities

α = experimental treatment effect

β = city effect

γ = season effect

ε = random effect from uncontrolled variation

It is necessary to test the null hypothesis that there are no differences among the four experimental treatments. The appropriate analytical technique is the analysis of variance. In the customary manner, the statistical significance of the above main effects will be appraised by computing the usual F-ratios. As indicated previously, the significance of possible interactions between the main effects cannot be tested with this design, nor does it seem worthwhile to employ the full factorial design which would be necessary to test this.

From the above test, it is expected that the null hypothesis will be rejected. The relative magnitudes of the differences between the four experimental treatments will be inferred from the consumption measurements.

Analogous hypothesis testing will be undertaken regarding the city effect and the season effect. If the cities are well matched, it is anticipated that the null hypotheses associated with these effects will not be rejected.

7. Budget and Schedule

This demonstration project is unavoidably associated with a major communications program to promote energy conservation. Similar programs have been undertaken in the past by federal government departments such as Energy, Mines and Resources. The total production and media costs for such a communications program would be many times the total of the remaining research costs of the demonstration project. For this reason, and also because the benefits from the communications program would extend beyond the research payoff, it seems appropriate to separate the research budget from that of the communications program.

Budget estimates for the research are shown in Table 7.1. Note that nearly one-third of the total consists of the cost of data collection. It is proposed that this be contracted directly between the data supplier and the Department, with the researchers providing the services needed to specify the data requirements.

Thus, the cost of the demonstration project, exclusive of data collection as well as production and media costs, is $63,250. However, this amount does include the cost of coordinating the research with both the communications program and the data-collection activities. Much of the principal researchers' time in the early stages of the project would be devoted to working with the advertising people to develop appropriate copy for each of the experimental treatments. Analogous collaboration would characterize the relationship between the principal researchers and the data supplier in the later stages of the project.

Table 7.1: Demonstration Project Budget Estimates: Information Strategy for Transportation Energy Conservation

Principal researchers' stipends		
detailed design and pretesting	35 person days	
monitoring measurement process	24 person days	
review and analysis of data	30 person days	
report preparation and presentation	26 person days	
	115 person days	$40,250.
Research assistants' stipends		9,000.
Computing, secretarial, copying, supplies, etc.		9,000.
Travel		5,000.
Subtotal excluding data collection		$63,250.
Data collection contract		29,000.
Total research cost		$92,250.

The total duration of the demonstration project is 24 months. This can be roughly broken down into the following parts:

design and pretesting	6 months
communication program and measurement	12 months
analysis, report preparation and presentation	6 months

The principal researchers would be prepared to start the project during the Spring of 1983.

POOR

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